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MICHIGAN AGRICULTURAL EXPERIMENT STATION QUARTERLY BULLETIN
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FEEDING AND CONFINEMENT REARING EXPERIMENT WITH TURKEYS DURING 1937

(Third Report)

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SECTION OF POULTRY HUSBANDRY AND LAKE CITY EXPERIMENT STATION

Rearing turkeys under confinement conditions demands a diet that is carefully balanced and that will adequately meet the requirements of the bird for body maintenance, growth and reproduction. In the development of suitable rations many factors must be considered, such as—palatability, normal development of body and feathers, rate of growth, health, vigor, physiological effect, finish, egg production, hatchability, availability of ingredients, ease of management, and feeding economy. Ration 7 has demonstrated its superiority over previous mashes in the foregoing respects and is now used as a check ration in the feeding trials, as well as being the one recommended to growers who wish an excellent all-purpose mash. A complete account of the work of the 1935 and 1936 seasons was reported in the Michigan Agricultural Experiment Station Quarterly Bulletin, Vol. 19, No. 1 (August 1936) and Vol. 20, No. 1 (August 1937).

1937 Objectives

As in the previous year, the 1937 feeding trials were mainly concerned with the lowering of feeding costs without limiting the development of the birds. The approach to this objective was made with rations 8, 11, and 12. Rations 8 and 11 are similar in that neither contains dried milk products and that both include corn gluten meal. In the 1936 trials, ration 8 produced relatively poor early growth accompanied by gray and rough feathering which apparently was due to a deficiency of vitamin G. Ration 11 is an attempt at correcting this condition by the addition of fish meal. Ration 12 was used in combination with ration 7 to answer the question as to the economy of using a ration relatively low in protein, after the eighth or twelfth week, with poults started on a high-protein ration. To meet the need for a ration in which barley completely replaced corn, both in the mash and grain part of the diet, ration 10, which is identical with ration 7 except for this substitution, was included in this year's feeding trials. The rations that were used and also the protein content of the mashes are shown in Table 1.

Incubation and Starting Methods

The poults used in these trials were hatched at the poultry laboratory at East Lansing from eggs produced by the breeding flock of Bronze turkeys at the Lake City Experiment Station. The first trial was made

Table 1. Rations.

RATION	7	8	10	11	12
PROTEIN CONTENT OF MASH	27%	25%	27.5%	28.5%	18.0%
Ground yellow corn	10	15	—	10	30
Ground barley	—	—	10	—	—
Ground oats	15	16	15	15	23
Wheat bran	10	13	10	13	20.5
Wheat flour middlings	10	12	10	13	—
Corn gluten meal	—	10	—	10	—
Meat scraps	14	10	14	10	6
Fish meal	—	—	—	10	—
Soybean oil meal	22	15	22	10	6
Dried skimmilk	10	—	10	—	6
Alfalfa meal	5	5	5	5	5
Calcium carbonate	1	1	1	1	1.5
Steam bone meal	—	—	—	—	1
Salt	1	1	1	1	1
***Cod liver oil	2	2	2	2	—
TOTAL	100	100	100	100	100
To drink	Water only	Water only	Water only	Water only	Water only
*Grain	Corn	Corn	Barley	Corn	Corn
**Green feed	Chopped Alfalfa	Chopped Alfalfa	Chopped Alfalfa	Chopped Alfalfa	Chopped Alfalfa
*Grit	Gravel	Gravel	Gravel	Gravel	Gravel

*Grain and gravel were added to the diet at the end of the seventh week.
**Chopped fresh alfalfa was given daily from the third week through the remainder of the experiment.
***Cod liver oil was discontinued after the sixteenth week.

with poults hatched May 7, with the exception of the combination ration 7-12 in which case poults hatched May 26 were used. A second trial was made with poults hatched May 26, except for those poults that were used with ration 7-12, which were hatched June 11.

The young poults were removed from the incubator when dry and placed in baby chick shipping boxes for the first 24 hours. At the end of that time they were placed under small brooders in the laboratory building in lots of about 40 poults each. Mash in hoppers, together with water in vacuum fountains, was the only food given for the first week, with the exception of a small amount of hard-boiled egg which was added to the diet during the first five days. Burlap was used for a floor covering for the first three or four days, until the poults were accustomed to eating mash, after which time fine shavings were used until the birds were removed to Lake City.

Experimental Pens at East Lansing

At the end of the first week the poults were sorted into experimental lots of 30 each. Each lot was provided with an indoor pen, 4½ feet wide and 10 feet long, with an electric hover. Perches were added when the hovers were no longer required.

Because the poults for the second trial were hatched about three weeks later than those of the first trial, it was necessary to remove the first lot to quarters in a laying house to give the preferred location in the laboratory to the younger birds. The birds remained in these quarters until removed to Lake City at the end of the seventh week.

The poults of the second trial remained in the quarters first mentioned until the end of the sixth week. With each trial it was necessary to keep the poults under the conditions described until their age and the weather conditions made it possible to transfer them to the large, open, turkey house at Lake City.

The Lake City Turkey House

At the Lake City Station, each lot of 30 turkeys was confined to a pen 10 feet wide and 24 feet deep in the open-front turkey house. This building, which is 100 feet long, is constructed of rough lumber and poles. The house is divided into 10 pens with wire and wood partitions. At the end and back walls are hinged panels that may be opened for summer ventilation. At the rear of each pen are perches and a dropping board. The floors are of concrete, and straw was used for litter.

Feeding Plan

In both trials, each of four of the pens of turkeys had its own distinct mash which was used for the entire period, and these are reported as Rations 7, 8, 10 and 11, respectively, and correspond to the mash formula number. The remaining pen, in each trial, received a combination of two mashes. In the first trial these birds were fed mash 7 until the end of the eighth week when a change was made to mash 12, and the pen was continued on this mash for the remainder of the 24 weeks. In the second trial, mash 7 was fed until the end of the twelfth week when a change was made to mash 12 for the remainder of the period. The two pens receiving this combination are reported as ration 7-12. Mash, gravel and water were before the birds at all times at Lake City, and grain was similarly provided for all pens after the first seven weeks. All pens received corn as the grain part of the ration with the exception of ration 10 which had only whole barley. Chopped fresh alfalfa was given daily in slatted racks.

Presentation of Results

Amount of Grain Consumed Influenced by Protein Content of Mash— Low protein mashes, which usually cost less per ton, do not necessarily produce cheaper gains than the somewhat more costly, high-protein mashes. When given a free choice there is a definite tendency for the birds receiving mashes of low protein content to consume a greater proportion of the mash and less of the grain than with mashes of the higher protein levels. There is also a natural tendency for turkeys to consume an increasing proportion of grain as they approach maturity. These tendencies are indicated by the data presented in Table 2.

Feed Consumed per Pound of Gain—One of the measures of the efficiency of a diet is the proportion of mash and grain, as well as the total quantity of these ingredients that is required to produce a unit of gain in weight in the birds. The average amount of feed consumed per pound of gain is given in Table 3.

Table 2. Proportion of mash and grain consumed.*

(Total mash and grain consumed equals 100)

Ration	Trial	0-4 Weeks		5-8 Weeks		9-12 Weeks		13-16 Weeks		17-20 Weeks		21-24 Weeks	
		Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain
7.....	1.....	100	0	97.5	2.5	86.7	13.3	75.8	24.2	64.0	36.0	46.0	54.0
	2.....	100	0	100.0	0.0	99.5	0.5	99.9	0.1	94.3	5.7	54.0	46.0
8.....	1.....	100	0	92.8	7.2	90.6	9.4	83.2	16.8	73.9	26.1	60.7	39.3
	2.....	100	0	99.0	1.0	100.0	0.0	94.4	5.6	70.3	29.7	44.3	55.7
10.....	1.....	100	0	91.3	8.7	84.8	15.2	68.7	31.3	52.1	37.9	40.0	60.0
	2.....	100	0	100.0	0.0	76.7	23.3	56.3	43.7	34.2	65.8	18.7	81.3
11.....	1.....	100	0	98.2	1.8	89.2	10.8	77.0	23.0	60.9	39.1	42.1	57.9
	2.....	100	0	100.0	0.0	99.1	0.9	85.4	14.6	60.1	39.9	33.5	66.5
7–12...	1.....	100	0	100.0	0.0	99.9	0.1	96.9	3.1	81.5	18.5	55.9	44.1
	2.....	100	0	100.0	0.0	98.1	1.9	88.4	11.6	76.3	23.7	54.8	45.2

*Mash in hoppers from the start. Grain in hoppers after the seventh week until the end of the period.

Average Cost of Producing a Pound of Gain—In determining the merit of any ration, the cost of producing a unit of gain should be considered. This information is given for each trial and for each ration in Table 4. Consideration should also be given to the normal development of the bird, the growth rate, physiological effect of the diet, the character of the finished product, and any other advantage or disadvantage of the particular ration before definite conclusions are drawn. Feed costs vary from one year to another because of changing feed prices. The price of feeds during the 1937 season while relatively high, was about 10 per cent lower than the previous year. This resulted in a corresponding lowering in the cost of producing a pound of gain.

Table 3. Pounds of feed consumed per pound of gain.

Ration	Trial 1					Trial 2				
	7	8	10	11	7-12	7	8	10	11	7-12
Mash.....	2.94	3.16	2.68	2.73	3.91	4.18	3.23	2.45	3.02	3.65
Corn.....	1.32	.94	—	1.33	.92	.71	1.04	—	1.38	1.06
Barley.....	—	—	1.69	—	—	—	—	2.51	—	—
Mash and grain total.....	4.26	4.10	4.37	4.06	4.83	4.89	4.27	4.96	4.40	4.71

1937 Feed Prices—The prices paid for the different mashes and grains are shown in Table 5. The relatively low cost of ration 8 is due largely to the addition of corn gluten meal and the elimination of dried milk. Ration 11 is the result of modifying ration 8 with a fish meal addition, to correct certain basic faults, and this accounts for the difference in

Table 4. Feed cost per pound gain.

Ration	Trial 1					Trial 2				
	7	8	10	11	7-12	7	8	10	11	7-12
Mash	$.076	$.071	$.070	$.068	$.084	$.109	$.073	$.064	$.076	$.082
Corn	.023	.016	—	.023	.016	.012	.018	—	.024	.019
Barley	—	—	.024	—	—	—	—	.035	—	—
Mash and grain total	$.099	$.087	$.094	$.091	$.100	$.121	$.091	$.099	$.100	$.101

price of these otherwise similar rations. The low cost of ration 12 is due primarily to a material reduction in protein supplements. The substitution of barley for the corn in mash 7 created mash 10 but with no change in price.

Table 5. Feed price.

Ration	Trial 1					Trial 2				
	7	8	10	11	12	7	8	10	11	12
Mash (ton)	$52.00	$45.00	$52.00	$50.00	$42.00	$52.00	$45.00	$52.00	$50.00	$42.00
Corn (bu.)	.98	.98	—	.98	.98	.98	.98	—	.98	.98
Barley (bu.)	—	—	.67	—	—	—	—	.67	—	—

Growth Rates—The average weights of both male and female turkeys at the end of the four-week periods are given in Table 6. The rate of growth of the different groups may be noted from the data presented.

Table 6. Growth of turkeys.

(Average weight in pounds)

Ration	Trial	4 Weeks		8 Weeks		12 Weeks		16 Weeks		20 Weeks		24 Weeks	
		M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
7	1	.80	.66	3.35	2.61	6.82	4.88	11.22	7.82	15.81	10.31	20.15	12.59
	2	.83	.75	3.30	2.83	6.59	5.08	10.76	7.93	14.54	10.32	19.03	12.25
8	1	.63	.61	2.69	2.41	5.62	4.84	9.54	7.83	13.60	10.59	17.65	12.86
	2	.78	.74	2.96	2.58	6.29	5.09	10.79	8.23	15.25	10.99	18.76	13.08
10	1	.74	.68	3.04	2.52	6.45	4.97	10.71	7.92	15.06	10.44	19.06	12.45
	2	.81	.80	3.00	2.70	6.28	5.26	10.60	8.23	15.08	10.82	19.08	12.33
11	1	.71	.69	2.91	2.67	6.09	5.19	10.38	8.14	14.86	10.57	18.74	12.76
	2	.80	.81	3.18	2.87	6.59	5.73	11.02	8.50	15.42	10.95	19.24	12.68
7–12	1	.69	.65	2.63	2.36	5.33	4.83	8.76	7.70	12.64	10.40	16.33	12.30
	2	.61	.60	2.52	2.21	5.90	4.78	9.95	8.00	14.62	10.65	18.29	12.48

Mortality—A total of 278 turkeys completed the 24 weeks of the feeding trials in good marketable condition out of 314 birds that were started. The total loss from all causes was 36 birds or 11.5 per cent, and this includes birds accidentally killed, stolen, or those removed because of injury or serious defect. Most of this loss occurred during the first few weeks and the loss after the twelfth week was negligible.

Observations—In the 1937 trials, ration 7 continued to give outstanding results throughout the entire feeding period. The birds were vigorous at all stages of growth and the feathering was smooth, lustrous and richly colored. The turkeys on ration 7 in the second trial, for some unexplained reason, consumed a greater amount of mash and a lower proportion of grain than is normal with this diet. The relatively small proportion of grain that was consumed, by this pen, during the first 20 weeks resulted in a higher cost per pound of gain than is usual with this ration. Ration 10, which is a modification of ration 7 with barley replacing the corn in both mash and grain, appeared to give equally as good growth, feathering and finish as ration 7.

During the 1936 trials, ration 8 gave unsatisfactory early growth which was accompanied by rough, dull, gray, weak-colored plumage. During 1937 this ration gave more satisfactory early growth and feather characteristics, but gray feathering was general by the fourth week. The analysis of the protein content was reported as 22 per cent in 1936 and as 26 per cent in 1937. Ration 11, which is essentially the same as ration 8 but for the addition of fish meal, gave very satisfactory results in growth and plumage characteristics in both trials and compared favorably with the best rations.

Ration 12 has a relatively low protein content and is typical of the usual chick growing mashes. Although low in cost this ration did not tend to produce such economical gains or such good finish, when fed after the eighth or twelfth week to poults started on ration 7, as did the ration fed the birds on the higher protein mashes.

There were very few cases of pendulous crop or crooked keels and these were not significant on any one diet.

Table 7.

Ration	Trial 1					Trial 2				
	7	8	10	11	7-12	7	8	10	11	7-12
Birds started	30	30	30	30	43	30	30	30	30	31
Surviving birds	28	25	30	28	37	27	27	22	26	28
Total weight	446.3	419.1	479.9	451.3	507.9	428.3	449.8	335.2	423.5	427.1
Number of males	10	14	16	14	13	14	15	4	13	13
Heaviest male	22.1	21.3	21.5	20.8	17.5	21.4	20.9	20.9	21.0	20.6
Lightest male	17.8	15.1	14.5	17.1	13.8	16.8	16.3	16.9	17.4	15.4
Average weight	20.15	17.65	19.06	18.74	16.33	19.03	18.76	19.08	19.24	18.29
Number of females	18	11	14	14	24	13	12	18	13	15
Heaviest female	14.8	15.5	16.4	14.8	14.0	13.4	14.2	13.8	13.7	15.0
Lightest female	10.0	11.5	11.0	11.6	10.3	10.0	12.0	9.3	11.4	11.1
Average weight	12.59	12.86	12.45	12.76	12.30	12.25	13.08	12.33	12.68	12.48

Final Weights—There were 278 turkeys that completed the feeding trials in good marketable condition. The turkeys on rations 7 and 10 were the outstanding birds as far as quality and finish were concerned. The turkeys on ration 11 were close to the best. Ration 8 produced birds that would rate fair to good. The turkeys on the ration 7-12 combination were good but lacked the best finish. There were only a few cases of crooked breasts and these were not significant on any one diet. The final weights of both male and female turkeys are given in Table 7.

Average Weekly Weights of Bronze Turkeys

These weights which are given in Table 8 are based on the results of six separate feeding trials conducted during 1935, 1936, and 1937 and include all turkeys surviving the 24-week period. The turkeys were reared under confinement during the brooding period at East Lansing and later in the open-front turkey house at the Lake City Experiment Station.

Mash 7 was hopper-fed during the entire period and corn was available for the birds at all times after the eighth week of age. Chopped alfalfa was given daily from the third week to the end of the trials. The birds had only water to drink. Gravel was provided for grit. Cod liver oil was discontinued in the mash after the sixteenth week.

Table 8. Average weekly weight of Bronze turkeys.

(3 years results)

Age in Weeks	Average Weight per Bird	Average Weight of Males	Average Weight of Females
1	.18	.18	.17
2	.29	.30	.27
3	.46	.48	.43
4	.71	.76	.66
5	.98	1.13	.83
6	1.50	1.62	1.38
7	2.14	2.30	1.97
8	2.78	3.01	2.55
9	3.39	3.70	3.07
10	4.10	4.51	3.68
11	4.79	5.34	4.24
12	5.59	6.25	4.93
13	6.46	7.21	5.71
14	7.28	8.20	6.35
15	8.20	9.30	7.09
16	9.04	10.32	7.76
17	10.03	11.53	8.53
18	10.89	12.59	9.18
19	11.80	13.76	9.83
20	12.60	14.83	10.37
21	13.53	16.02	11.04
22	14.42	17.15	11.68
23	15.08	18.01	12.14
24	15.85	19.12	12.58

Average amount of mash and grain consumed per pound of gain:

Mash	3.11 lbs.
Grain	1.30 lbs.
TOTAL	4.41 lbs.

A Cobblestone Turkey Yard—The first cobblestone turkey yard was constructed at the Lake City Station in 1937. It seems to offer a simple yet promising method of yarding turkeys for the control of Blackhead. This is a permanent yard, 75 feet square, and for convenience, adjacent to the main turkey house. It is provided with an inexpensive shelter which will accommodate from 75 to 100 turkeys to maturity. The yard proved so satisfactory during the first year that a second one of the same size was established in 1938.

The essential feature of the yard is that the ground is covered with stones that vary in size from one to three inches in diameter. A three- or four-inch layer of these stones is spread over the lot so that the

Fig. 1. Cobblestone yard and cheap summer shelter.

turkeys do not come in contact with the surface soil. Each rain washes off the droppings and the yard looks clean, even during the summer months when rains are less frequent. The turkeys also have clean feet. Each spring the stones are loosened with a spring-tooth harrow and occasionally more stones may be added. The stones are obtained from a gravel pit and are the larger screenings that are rejected in the production of road gravel. They usually can be had for the hauling. A view of such a yard is shown in Fig. 1.

Summary

There is a definite tendency for turkeys on low-protein mashes to consume a greater proportion of the mash and a smaller proportion of the grain than is the case with the higher protein mashes.

There is a general tendency for turkeys to consume a greater pro-

portion of grain and a smaller proportion of mash as they approach maturity.

Ration 7 continues to produce thrifty turkeys with smooth, lustrous, plumage and excellent market quality. This is recommended as an excellent all-purpose mash for starting baby poults and for the development of turkeys of excellent quality at moderate cost.

Ration 10 may safely be recommended to the barley farmer who wishes to substitute barley for corn in both mash and grain. It is a modification of ration 7 and is similar to this ration in essential ingredients and results.

Ration 8 is not suitably balanced for the most satisfactory development of birds and is not recommended. It is especially undesirable as a starting ration and also tends to be constipating. Although ration 11 apparently gave satisfactory growth and finish this first year, it will not be generally recommended without further trials.

As a result of this year's work it would appear that there is little if any economy or advantage in feeding a low-protein mash, similar to a chick growing mash, to turkeys after they have been started for the first eight or twelve weeks on a high-protein ration.

FROST HARDINESS OF SOME TREES AND SHRUBS FOR FOREST PLANTING IN SOUTHERN MICHIGAN

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Section of Forestry

The late spring frosts which occurred through southern Michigan on May 12 and 13, 1938 provided an excellent test of the frost hardiness of various tree and shrub plantings made on the Kellogg reforestation tract of Michigan State College. This tract is located in Kalamazoo County, eight miles northwest of Battle Creek, Mich., and near the town of Augusta. Conditions are probably typical of southern Michigan.

Weather during the spring period was somewhat abnormal. An unusually warm period occurred during latter March, causing the swelling of buds and the beginning of new growth by a number of species. Intermittent periods of cool and warm weather allowed a gradual advance of growth until by May 12 many of the species were well in leaf.

Weather bureau data at Battle Creek, and at the Kellogg farm two and one-half miles from the reforestation tract show that temperatures of 28° F. occurred on May 12 and again on May 13. Because the reforestation tract is located partly in the valley of Augusta Creek, temperatures there were lower than 28° F. Unofficial records indicate that valley temperatures of 25° F. and 26° F. occurred on May 12 and 13. It is well known that cold air drainage often causes temperatures in low areas to be lower than on adjacent higher areas. No killing frost occurred during the spring after May 13.

While the season may be considered abnormal, it does not represent an entirely unusual condition. Damaging late spring frosts occur periodically and may be expected to occur during certain years. Trees must be adapted to withstand such frosts in order to be used successfully in forest plantations. It is the extreme conditions such as late spring frosts that determine the suitability of a species for growth in a given locality or region.

Observations on frost hardiness were made on 47 different species of forest trees and shrubs planted on the tract. Most of the plantations were young, having been planted as small seedlings or transplants during the period 1935-37. The oldest plantations date back to 1931-32.

Amount of frost damage was classified under three categories as follows:

(1) **Damage None or Slight**—Species in this category proved resistant to frost damage under all conditions and showed little or no killing of leaves or other tissues.

(2) **Damage Moderate**—In this group species showed some damage by frost, especially on low sites. From 25 to 50% of new leaves and opened buds or succulent growth were killed.

(3) **Damage Heavy**—Practically all new growth and opened buds of species in this group were killed. Damage was severe even on the higher sites. In some cases older growth, woody tissues one or several years old, was killed.

On the basis of these three categories the species may be classified as (1) frost hardy, (2) moderately frost hardy, and (3) not frost hardy. This classification has particular reference to frost hardiness of the species considered here during the early spring growing period. It should not be taken to mean that species classified as "not frost hardy" can not be grown successfully in this region. In fact, once established, all of these species will grow reasonably well in southern Michigan.

In Table 1 the 47 species of trees and shrubs studied at the Kellogg reforestation tract are classified according to frost hardiness.

Table 1. Frost hardiness of trees and shrubs at Kellogg reforestation tract.

Frost Hardy	Moderately Hardy	Not Frost Hardy
Russian olive	white spruce	black walnut
Siberian pea tree	Macedonian pine	butternut
tamarack	European larch	red oak
red maple	pin cherry	white oak
sugar maple	mountain ash	black locust
wild plum	black cherry	honey locust
red osier dogwood	basswood	white mulberry
Scotch pine	Chinese elm	American chestnut
red pine	Amur river privet	hackberry
jack pine	cornelian cherry	northern pecan
Austrian pine	*hybrid poplars	*hybrid walnuts
northern white cedar	Norway spruce	English walnut
ponderosa pine	indigo bush	chinquapin
pitch pine		Douglas fir
red spruce		white ash
Japanese red pine		green ash
Nanking cherry		
Tartarian honeysuckle		

*Includes several species or varieties of similar frost hardiness.

Frost Hardiness Varies With Species

Frost hardiness varied considerably among the different species. Native conifers and hardwoods, particularly those whose natural range extends through northern Michigan, are among the frost hardy. Also included in this group are species introduced from regions having climates as severe as or more severe than the climate of central Michigan.

Moderately hardy species include some of the native hardwoods along with a number of exotic introductions and several native species: white spruce, mountain ash, and pin cherry, whose principal ranges are farther northward.

In the "not frost hardy" group are many species introduced from central United States along with some of the less hardy native hardwoods, a few hybrid species and one conifer from western United States. Though species varied greatly in frost hardiness, the extent of variation within a species appeared to be slight.

Native species growing naturally on low sites in Michigan were among the most frost hardy species. Tamarack, red maple, northern white cedar and red osier dogwood are such species.

Foliage of the indigo bush was frozen back completely wherever it appeared, but for the most part buds of this species had not opened, and damage as a consequence was very slight. The opening of the buds at such a late date in this species resulted in its classification as fairly hardy. In relation to resistance of the foliage to freezing it would be classified as not hardy. Walnut and butternut buds had just begun to open at the time of the frosts. Practically all one- and two-year seedlings of these species were killed back to the ground. Year-old wood was killed in the case of older trees of these species.

European larch with leaves only slightly elongated proved very resistant to frost damage, but trees with advanced foliage growth were severely damaged, and in some cases the trees were killed.

Douglas fir appeared particularly susceptible to late spring frosts. About 75 per cent of the new shoots were killed, and approximately 20 per cent of the trees died as the result. Trees in many cases were weakened, necessitating additional care to ensure their survival. A variety of Douglas fir which would begin growth later in spring therefore would be much better adapted for southern Michigan conditions.

Most of the conifers, especially the pines, were frost hardy, although some damage did occur. Occasional buds or new growth on white pine appeared dried or shriveled. Growth of damaged shoots was usually stunted; the more severely damaged shoots were killed and later turned black. The same occurred to a considerable extent with the introduced Macedonian pine. When the first new shoots were frozen, only weak, adventitious shoots were formed to take their place.

Occasionally the first needles to appear from the opening buds of red and Scotch pine were killed by the frost, but the main shoot remained undamaged. Thus the upper part of the leader in these species would be bare of needles, or the needles would remain very short in contrast with the normal length of the needles not damaged by frost.

Frost Hardiness Due to Several Factors

In some species frost hardiness appeared due to the ability of new growth to resist freezing. Sugar maple, red maple, Russian olive, Siberian pea tree, tamarack, and red osier dogwood, for example, had well developed leaves at the times when the frosts occurred. Yet the leaves were not damaged.

Frost hardiness in other species seemed to be due to the late opening of the buds. Of red, Norway, and white spruces, red spruce alone escaped injury because the buds were just beginning to open at the time of the heavy frosts, whereas Norway spruce and white spruce, with many buds opened and advanced growth appearing, suffered extensive freezing back of succulent growth. Norway spruce, however, suffered more severely than white spruce, the succulent growth of the former apparently being more susceptible to frosts.

Thus frost hardiness as here considered is due either to the ability of new growth to resist freezing or ability of the plant to escape the late frosts by remaining in the winter dormant condition until danger from frosts is over.

Topography Influences Severity of Frost Damage

Frost damage was found to vary greatly between ridge and valley sites, being much more severe on valley sites. In general, the lower the elevation, the more severe was the frost damage. Upper slopes and ridges showed relatively little damage as compared with lower slopes and valleys. Basswood and oak, for instance, had all foliage completely killed on valley and lower slope sites, but slight damage occurred on middle and upper slopes.

It seems probable that failure of black walnut, red oak, basswood, Douglas fir and Norway spruce to effect good establishment on low sites at the Kellogg reforestation tract has been due largely to repeated frost damage.

Summary

A study was made of frost hardiness of forty-seven species of forest trees and shrubs at the Kellogg reforestation tract.

Species were classified in three categories as (1) frost hardy, (2) moderately frost hardy, and (3) not frost hardy.

Species were found to vary considerably in frost hardiness.

Frost hardiness was observed to be due in some species to resistance of new growth to freezing. In others it was due to late opening of buds, thus avoiding exposure of new growth to frosts.

Severity of frost damage varied considerably according to topography, being much more severe on lower slopes and valley lands than on upper slopes and ridges.

Frost damage may deform, weaken or kill forest tree and shrub plantings. Establishment may be delayed or prevented. Additional care may be required to ensure survival of damaged trees because of competition from other plants.

For best results in forest plantings, only frost hardy trees should be planted on low sites where danger from frosts is great and plantings of species not frost hardy should be limited to upper slopes and ridges where there is less danger from frosts.

GROUND ALFALFA VS. TANKAGE FOR SOWS

V. A. FREEMAN
SECTION OF ANIMAL HUSBANDRY

Ground alfalfa was compared in efficiency and cost with tankage as a supplement to corn for brood sows during the gestation period. Four trials were completed in successive seasons from December 1932 to the spring of 1936.

The sows and gilts were divided as evenly as possible into two lots considering age, breeding, development, and in the case of the older sows, previous production records. Gilts bred to farrow their first litters at one year of age and thinner or timid sows were fed separately. The daily feed allowance was regulated so as to bring the sows into ideal condition at farrowing time.

Choice quality second-cutting alfalfa hay was ground and mixed with ground grain for the alfalfa lot in the proportion of one part of alfalfa and two parts of grain, while the other lot received approximately 6 per cent of tankage with their grain. Corn was the only grain used in the last three trials. A grain mixture of two parts corn and one of oats was used in the first trial. Both lots were given access to a rack of alfalfa hay of the same quality as the ground alfalfa, and had before them a mineral mixture of equal parts of limestone, bone meal and salt. The grain mixtures with ground alfalfa and tankage were hand-fed in an effort to produce the same rate of gain and condition of flesh for similar age groups of both lots.

The average rate of gain, feeds consumed, and cost computed on a 114-day basis are given in Table 1. The sows and gilts receiving ground alfalfa with their grain consumed from the rack 36 pounds of hay per sow, while those receiving the tankage consumed only 43 pounds of hay. The tankage-fed lot gained 0.14 pound more per sow daily. More total feed was required by the alfalfa-fed lot. The 243 pounds

Table 1. Gains and feed required by sows during their gestation period.

	Tankage	Alfalfa
Number of sows and gilts	63	59
Average daily gain	1.08 lbs.	.94 lbs.
Average weight at farrowing	507 "	506 "
Feeds consumed (114 days) per sow:		
Corn	604 "	486 "
Tankage	39 "	.....
Ground alfalfa	.....	243 "
Alfalfa hay	43 "	36 "
Oats	60 "	59 "
Bran	6 "	.....
Minerals	6 "	7 "
Feed cost per sow	$7.42	$6.93

of ground alfalfa fed to them replaced 119 pounds of grain, 39 pounds of tankage, 6 pounds of bran, and 7 pounds of loose hay. Bran was fed to the tankage lot the last few days before farrowing to overcome a tendency toward constipation.

Feed prices charged were grain (corn, oats and bran) $20 per ton; tankage $45; alfalfa $7, plus $3 for grinding; and minerals 2 cents per pound. At these prices, the feed cost per head for the alfalfa lot was $6.93 as compared with $7.42 for the tankage lot, a saving of 49 cents per sow.

The pigs were individually marked, weighed and graded for apparent strength and vigor before they were 24 hours old. The average farrowing results are given in Table 2.

Table 2. Farrowing results.

	Tankage	Alfalfa
Number of pigs per litter	8.6	9.3
Number of strong pigs	6.2	6.4
Number of medium pigs	1.2	1.6
Number of weak pigs	.5	.6
Number of still-born pigs	.6	.7
Percentage of strong pigs	72.7	68.8
Percentage of medium pigs	14.2	16.6
Percentage of weak pigs	5.8	6.7
Percentage of still-born pigs	7.3	7.9
Weight per litter	23.4 lbs.	24.9 lbs.
Weight per pig	2.73 "	2.68 "

The slightly larger number of pigs produced per litter by the alfalfa-fed sows probably accounts for the small advantage in litter weight, and disadvantage in weight per pig. The advantage which the tankage-fed sows had in strength of pigs was undoubtedly due to the smaller litters produced by this group. Of the pigs produced by the alfalfa-fed sows, 85.4 per cent were strong or medium-strong as compared with 86.9 per cent strong and medium-strong pigs produced by the tankage-fed sows.

There is no material difference from the foregoing comparative results when the data for the mature sows is separated from that for the gilts farrowing their first litters at one year of age, except that the sows of both lots farrowed larger litters of heavier pigs than the gilts, but with more weak and still-born pigs. The gilts saved a larger percentage of their pigs until weaning time and weaned approximately the same number of pigs per litter as the sows, but their pigs gained slower, weighing nearly 10 pounds less at 56 days of age than those from the sows.

There was little difference in the apparent milking ability of the two lots of sows and gilts. Both lots of sows and their pigs received tankage as a protein supplement during the nursing period, since previous tests at this Station had shown very poor results when alfalfa was the only supplement used with corn and oats for nursing sows and young pigs.

These results indicate that second-cutting alfalfa hay of good quality may be used successfully as the only supplement to corn or corn and oats for sows and gilts during the gestation period. Corn was used in these trials in order to determine the practicability of supplementing a

low-protein grain with alfalfa. A variety of feed usually shows best results. It is, therefore, good policy when oats, wheat, or barley are as low in price as corn to feed a variety of grains to breeding animals.

ELECTRIC DAIRY WATER HEATER AND UTENSIL STERILIZER

D. G. EBINGER
Section of Agricultural Engineering

Michigan's dairy industry produces a large part of the state's total farm income. This income could be increased by saving the thousands of dollars which are lost annually due to rejected milk—milk that is sour or off-flavor.

One of the great contributing causes of low-grade dairy products and sour milk is the unsterilized utensil. The bacteria which cause this souring, production of off-flavors and sometimes sickness multiply very rapidly on the moist surfaces of unsterilized pails, strainers and cans.

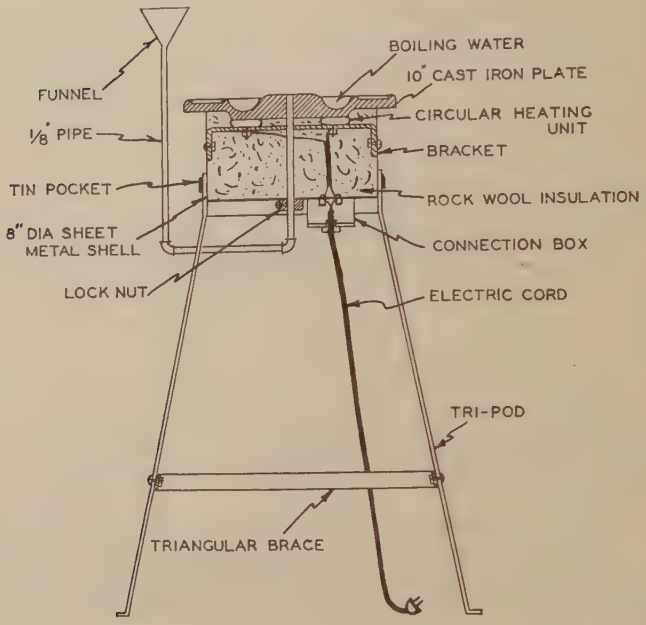
The demand for higher quality dairy products has caused many farmers to sterilize all of their milk handling equipment as an insurance against loss from souring or a low-grade product. That demand has stimulated an interest in hundreds of other farmers for an effective, low-cost electric sterilizer.

It should be remembered, however, that sterilization does not take the place of washing. Utensils which have not been properly washed commonly carry large numbers of bacteria in the particles of milk or butterfat which remain. Utensils are much easier to wash immediately after being used rather than letting the milk or cream to dry on the surface. They should first be rinsed with cold water. This prevents the milk solids from "cooking" on the utensils, reduces the amount of washing powder necessary and helps to keep the wash water clean. After thorough washing and rinsing in hot water, the utensil is ready for sterilization.

To have hot water available in the barn or milk house for washing of the utensils is a problem on many Michigan farms. Owing to the fire hazard associated with the use of an oil, wood or coal burning stove the water used for washing pails, cans and strainers is heated either on the kitchen stove or in an electric household water heater. This water may be efficiently hot to do a good washing job as it leaves the house but while being carried through the yard to the barn it rapidly loses its effectiveness.

To provide hot water (180° F.) at the place where it is to be used and further provide for effective sterilization of dairy utensils, the Agricultural Engineering Section has designed a portable combination electric water heater and sterilizer (Fig. 1).

This unit is a relatively simple piece of equipment, consisting of an 1,000- or 1,500-watt heating element which, except for the top heating



DAIRY WATER HEATER AND STERILIZER

Fig. 1. Dairy water heater and sterilizer.

surface, is packed in fireproof insulation. A specially designed plate is placed over this element and fastened directly to it. This plate is one of the unique features of the unit.

Normally a heating unit is a flat plate over which a pan or pail of water is placed. This makes an effective medium provided the pan or pail has a perfectly flat bottom and makes a good contact with the heating element. The average farm pail, however, does not have a flat bottom, rather it is "dished" or may be otherwise bent. A pail with the bottom just described would not contact a heating plate in its entirety and would provide an air space between the heating plate and the area to be heated, thus effecting a layer of air insulation between the two which would decrease the efficiency of the heater by increasing the time necessary to heat the water. (Fig. 2.) To overcome this difficulty the heating surface or plate on this unit is designed with a circular depression which, in operation is filled with water. This water is rapidly heated and is converted to steam. The steam rises, contacts the cold surface of the pail and condenses. As the steam condenses, a drop of water is formed which drips back onto the heated plate and is again converted into steam. This process continues until the water in the pail is heated. The whole heater assembly may be mounted on tripod legs or may be built into a table.

The use of this heater fits perfectly into the operating routine of the average farm dairy. Just before starting to milk, the dairyman

places approximately one-quarter pint of water in the depression built into the heating plate, places the pail of water which will later be used for washing purposes over the plate and turns on the current. The wash water is hot by the time the milking is done and the milk cooled (see Table 1). It is recommended, for efficient operation, that the pail be equipped with an insulated cover which may simply be a piece of ½" thick insulating board cut to fit the top of the pail. This cover should be strengthened and protected by the addition of galvanized sheet iron to either side of the insulating board. As the cans and pails are washed and rinsed they are inverted over the heated plate. A small amount of water is again placed on the plate by means of the funnel mounted on the side of the unit. This water is quickly converted to steam and fills the interior of the utensil with low-pressure, moist steam. With the 1,500-watt element the time required to raise the temperature of a 10-gallon can to 200° F. is about two and one-half minutes. With this unit it is easily possible to sterilize quickly cans and other dairy utensils immediately before milking, thereby eliminating a source of bacterial contamination.

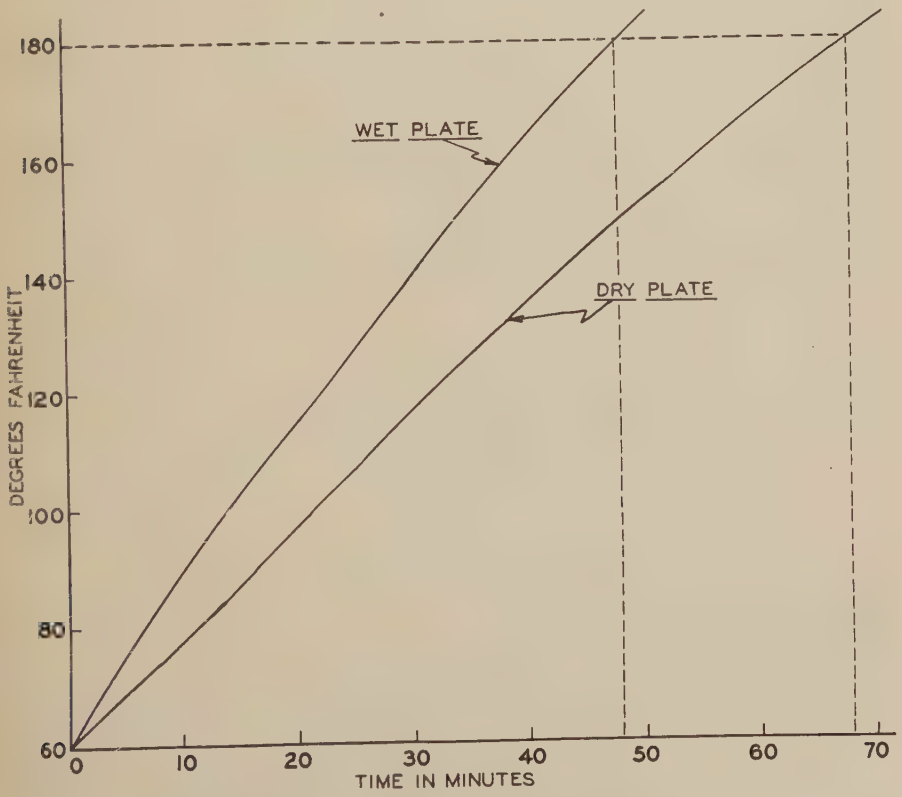


Fig. 2. Time required to heat 8 quarts of water with a unit heater of 1000 watts.

Table 1. Time necessary to heat various quantities of water* 1000 watt heating element.

Amount of water in quarts	Time (Minutes) to heat from 60° to 180° F.	
	Insulated cover on pail	No. cover on pail
2	9.5	10.5
4	22.0	25.8
6	34.0	39.0
8	48.0	54.5
10	63.0	77.0

*One-quarter pint water used on heating plate in all of above trials.

One of the chief objections to dairy equipment steam sterilizers of the past has been the high operating cost. This new development in sterilizers is efficient. Several experimental models have been under observation for some months; one in particular has been heating 2 gallons of water twice daily plus the sterilization of cans and mechanical milking equipment for an 18-cow dairy on a monthly kilowatt hour consumption of 52.8.

Milking machines and milk utensils properly washed and adequately sterilized on the farm with a safe, clean, odorless and efficient electric water heater and sterilizer will do much toward increasing the quality of milk. This quality will be reflected in increased demand which eventually will benefit the farmer financially.

Additional information may be obtained by writing to the Agricultural Engineering Department, Michigan State College.

PREVALENCE OF WILT DISEASES IN MAPLE AND ELM

FORREST C. STRONG
Section of Botany

Elm and maple trees are affected by several diseases which are accompanied by wilting as one of the symptoms exhibited at some stage in the progress of the malady. There are a number of parasitic organisms capable of producing a diseased condition in elm with symptoms of wilting. Two of the most important elm pathogens native to this country are *Verticillium* sp. and *Dothiorella ulmicola* (formerly known as *Cephalosporium* sp.). Other species of fungi that have been found capable of causing elm trees to wilt and branches to die are *Sphaeropsis, Coniothyrium,* and *Vermicularia.*

The most serious pathogen which causes wilt in elm is the Dutch Elm Disease fungus, *Ceratostomella ulmi.* This fungus was introduced into the United States from Europe, and has produced a severe epidemic in

the vicinity of New York. Other lesser outbreaks have occurred, the nearest to this state being in Cleveland, Ohio, and Indianapolis, Ind.

Verticillium is the only known parasitic fungus causing wilt in maple. It has been proved to be the same fungus that infects elm as well as Japanese barberry and other ornamental shrubs.

Wilting and dying of the branches of elm and maple may also be brought about by non-parasitic causes. Deficient water supply due to drouth or root injury as well as the presence of illuminating gas in the soil, and suffocation of roots by packing of the soil produce these same symptoms.

Confusion between wilts of a parasitic and a non-parasitic nature may be avoided by examining a smooth cut made across the affected twig or branch. The presence of green (maple) or brown (elm) flecks and streaks in the wood indicates the presence of a parasitic fungus while the absence of discoloration indicates a non-parasitic trouble.

Because of the similarity of symptoms exhibited by the several fungi causing elm wilt, the exact diagnosis of this disease cannot be made in the field, but specimen pieces from affected branches must be collected and submitted to a plant pathological laboratory where a careful technical procedure is necessary to identify the pathogens.

The following observations on the prevalence of wilt diseases in maple and elm in Michigan are based on the specimens of wilting trees that have been submitted to the plant pathological laboratory of the Michigan State Agricultural Experiment Station for examination and diagnosis during the summer of 1938. A careful cultural and microscopic study was made of specimens from 51 cases of dying American elm located in various parts of the state. Specimens were submitted by city foresters, commercial shade tree men, and tree owners, and are believed to represent a fair cross section of the diseased elm in this state. Study of these specimens shows that 31% of the cases were infected with *Verticillium* wilt, 5% with *Dothiorella* wilt, 2% with *Coniothyrium* wilt, 2% with *Sphaeropsis* canker, and 0% with the Dutch Elm Disease. In 41% of the cases no fungus was found. When no fungus is found present, wilting may be assumed to be due to non-parasitic causes.

In a report from the Dutch Elm Disease Laboratory, Morristown, N. J., Dr. Curtis May states that to date no specimens infected with the Dutch elm disease have been received from Michigan.

A study of *Verticillium* wilt of maple was carried on during the last

Table 1. Prevalence of diseases in American elm.

	Number of cases	Per cent diseased
Verticillium wilt	16	31%
Dothiorella wilt	3	6
Coniothyrium wilt	1	2
Sphaeropsis canker	1	2
Dutch Elm Disease	0	0
Non-parasitic causes	30	60%
Total cases	51	

summer in Lansing as a representative city. Fifty-three cases of maple wilt were investigated. The relative prevalence of *Verticillium* wilt and wilts due to non-parasitic causes in hard and soft maples is recorded in the following table:

Table 2. Prevalence of Verticillium wilt in maple.

Variety	Number of cases Investigated	Number of cases of Verticillium wilt	Per cent of cases of Verticillium wilt	Number of cases of wilt non-parasitic	Per cent of cases of wilt non-parasitic
Norway Maple	42	18	42%	24	58%
Hard Maple	10	2	20	8	80
Silver Maple	1	0	0	1	100
Total	53	20	—	33	—

The greater susceptibility to infection by *Verticillium* of Norway maple, as compared with hard maple is shown by the foregoing figures. Of the actual *Verticillium* infections found, 90% were on Norway maple while only 10% were on hard maple.

Carl Fenner, assistant city forester of Lansing, estimates that there are 3,500 Norway maple trees (excluding recently set out trees) planted along streets and in parks of that city. On the basis of his estimates it is probable that 0.5% of the Norway maples are affected with *Verticillium* wilt.

While the actual number of elm and maple trees affected with wilt diseases is small, the interest of the general public in our shade trees is considerable and advice on the control measures applicable to these troubles is frequently requested. Such control measures as are known will be briefly outlined.

In the case of parasitic diseases, the prompt pruning of dead and dying branches is of first importance. If the wilt fungus is located in or has extended its growth into the main stem, the affected tree is likely to die in a few years. This is especially true when an elm tree is infected with *Dothiorella*. When elm and maple trees are found to be infected with the *Verticillium* fungus, prompt pruning of infected branches followed by fertilization with a commercial fertilizer to stimulate the growth of the tree often brings about an apparently complete recovery from this disease. The application of soil-soaking waterings during the hot dry months of summer is also very beneficial in aiding infected trees to recover. Whether trees which apparently recover will later show symptoms of disease again is not known.

Elm trees infected with the Dutch elm disease fungus must be removed promptly and the parts burned since this pathogen will kill any elm tree it infects and will spread readily to other elm trees, killing them.

In the case of non-parasitic troubles, soil-soaking waterings will overcome the effects of drouth, and aeration of packed soils by loosening of the soil or use of compressed air will alleviate the effects of suffocation. Fills over the roots of trees, especially maple, should be avoided. Presence of illuminating gas in the soil for any length of time usually results in the killing of trees. Prompt discovery and

mending of leaks in gas mains followed by aeration of the soil with compressed air machines to drive out the injurious accumulation of illuminating gas may prevent killing of trees by this agent. Injury to main roots of trees in construction work should be avoided if the tree is to be saved.

CHERRY TREE MORTALITY IN SIX MICHIGAN COUNTIES FROM 1930 TO 1938

G. N. MOTTS
SECTION OF ECONOMICS

A study of cherry production in Michigan in respect to the number of bearing and non-bearing trees in the state was published by this station in 1933 (1).[1] It was followed in 1935 by one dealing with production and price trends in the pitted red cherry[2] industry (2). These two studies and the present paper are reflections of the importance of cherries in the horticulture of Michigan and of the continued interest among growers and processors in the status and trends of cherry production in the leading red cherry producing state in the country. A further reason for the present paper is that although at least three papers have been published in recent years on the length of life or tree mortality of apples in commercial orchards (3, 4, 5), no comparable study seems to have been made of red cherry tree mortality.

Scope and Method—In 1930 the 11 important cherry producing counties in Michigan[3] contained 87 per cent of the trees in the state, and the data in the present study were obtained in the two most important counties of each of the three producing areas.[4] These six counties included 80 per cent of the orchards and of the total number of trees in the 11 commercial counties in 1930. The data in the present study include red cherries only, since sweet cherries represented only 5 per cent of the state total in 1930. Since 95 per cent or more of the red cherry trees in Michigan are of the Montmorency variety (1), the data presented may be considered to be for that variety, although several blocks of the Early Richmond and English Morello varieties are included. The time included in the tree mortality data is the nine-year period from 1930 to 1938, inclusive.

The individual farm record sheets and township plat maps secured in 1930 were used as the basis of this project. The continued existence of each block of trees or the loss or abandonment of entire blocks was

[1]The figures in parentheses indicate references in the Literature Cited section at the close of the paper.

[2]The term red cherry is used in preference to sour cherry because the latter is regarded as a handicap by the industry.

[3]Southern area: Berrien, Van Buren, Allegan. Central area: Oceana, Mason, Manistee. Grand Traverse region: Benzie, Leelanau, Grand Traverse, Antrim, Charlevoix.

[4]Southern area: Berrien and Allegan. Central area: Oceana and Mason. Grand Traverse region: Leelanau and Grand Traverse.

checked for each farm reported to have had commercial plantings[1] of cherry trees in 1930. It was not feasible to obtain a record of trees lost in each block on each farm where no entire blocks had been lost or abandoned, but such records of scattered trees lost during the period were obtained from 20 growers located in the more intensively planted townships of each of the six counties. The term "block" in this study means all of the trees of the same age on one farm.

Mortality of Entire Blocks

The number of blocks, the acreage involved and the percentage of the total acreage of abandoned blocks of cherry trees in each of the six counties are included in Table 1, and the percentage attributed to each group of factors is also presented in Fig. 1. The number of trees originally present in these blocks which have disappeared since 1930 can be closely approximated by omitting the decimal points in the acreage columns; i. e., the five blocks of trees lost from winter injury in Berrien County contained about 367 trees.

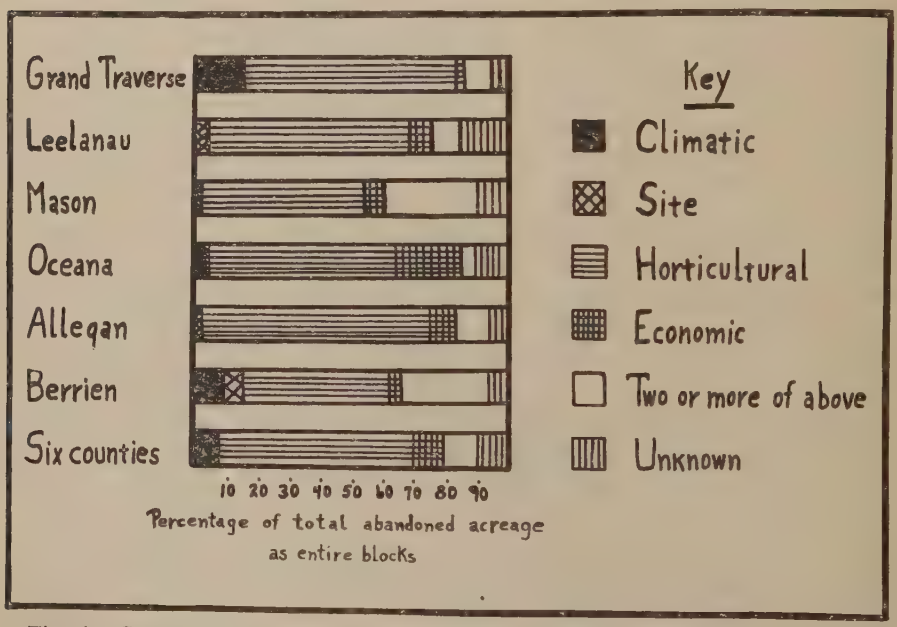


Fig. 1. Comparative importance of different groups of factors causing the abandonment of 250 blocks of cherry trees in six Michigan counties, 1930-38.

Climatic Factors—For the six counties as a whole the acreage lost from winter killing was more than twelve times as great as that removed because of frequent frost damage to blossoms or fruit. The two factors combined, however, accounted for less than 5 per cent of the acreage of abandoned blocks of trees. The importance of good air

[1]Orchards of 50 or more trees in Berrien and Allegan counties and of 200 or more trees in the others.

Table 1. Comparative importance of causes of abandonment of entire blocks of trees in six Michigan counties, 1930 to 1938.

Causes of Abandonment	Berrien			Allegan			Oceana			Mason			Leelanau			Grand Traverse			Totals		
	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres	No. of Blocks	Acres	Per cent of Abandoned Acres
CLIMATIC FACTORS:																					
Winter injury	5	3.67	8.7	—	—	—	—	—	—	1	1.50	2.1	—	—	—	1	20.00	14.7	7	25.17	3.8
Frost injury	—	—	—	—	—	—	1	2.00	1.0	—	—	—	—	—	—	—	—	—	1	2.00	.3
SITE FACTORS:																					
Unfavorable soil	1	1.00	2.4	2	2.00	2.1	1	.50	.3	—	—	—	1	5.00	4.0	—	—	—	5	8.50	1.3
Unfavorable topography	1	1.50	3.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1.50	.2
HORTICULTURAL FACTORS:																					
Old age	6	5.00	11.8	11	13.30	14.1	6	12.00	6.3	4	8.35	12.0	2	10.00	8.0	11	49.50	36.3	40	98.15	14.9
Interplanted	3	2.50	5.9	1	3.00	3.2	4	18.50	9.7	—	—	—	—	—	—	—	—	—	8	24.00	3.7
General neglect	8	6.10	14.4	20	34.70	36.9	10	41.16	21.5	20	20.66	29.5	5	42.50	34.3	10	34.25	25.1	73	179.37	27.3
Inadequate spraying	5	5.50	13.0	3	9.25	9.8	11	24.75	12.9	2	5.25	7.5	—	—	—	3	8.00	5.9	24	52.75	8.0
Combination of these factors	2	1.00	2.4	6	7.60	8.1	6	25.50	13.3	1	2.00	2.9	2	26.50	21.4	1	1.50	1.1	18	64.10	9.7
GROUP TOTAL	(24)	(20.10)	(47.5)	(41)	(67.85)	(72.0)	(37)	(121.91)	(63.7)	(27)	(36.26)	(51.9)	(9)	(79.00)	(63.7)	(25)	(93.25)	(68.4)	(163)	(418.37)	(63.6)
ECONOMIC FACTORS:																					
Low cherry prices	1	1.00	2.4	1	2.00	2.1	—	—	—	—	—	—	—	—	—	—	—	—	2	3.00	.4
Farm abandoned	—	—	—	2	6.00	6.4	8	35.75	18.7	3	3.75	5.4	1	9.00	7.3	1	2.00	1.5	15	56.50	8.6
Factors in two or more groups*	5	12.00	28.4	7	10.30	10.9	7	10.25	5.3	12	21.15	30.2	1	11.00	8.9	4	14.00	10.3	36	78.70	12.0
Unknown	3	3.00	7.1	2	6.00	6.4	4	21.00	11.0	5	7.30	10.4	2	20.00	16.1	4	7.00	5.1	20	64.30	9.8
GRAND TOTAL	40	42.27	100.0	55	94.15	100.0	58	191.41	100.0	48	69.96	100.0	14	124.00	100.0	35	136.25	100.0	250	658.04	100.0
Per cent of 1930 Acreage	.....	2.68	.....	.....	9.21	.....	.....	4.95	.....	.....	10.36	.....	.....	3.60	.....	.....	2.84	.....	.....	4.28	.....

*Also includes a few cases of poor nursery stock and of rabbit and mice injury.

drainage in reducing the risk of loss from winter killing is well illustrated by the seven cases included in Table 1. Of the seven blocks of trees one was on low lying flat land, three on plains with slopes of 3 per cent or less, two on broad ridges with slopes of 8 per cent or less rising from a broad plain, while only one was located on a site with predominant slopes of 15 per cent or more.

Site Factors—Unfavorable soil and topography were the least important single causes of the disappearance of entire blocks of trees. The explanation seems to be that while cherries generally thrive better on the lighter sandy or gravelly loam soils, they are relatively tolerant to other types, and their successful cultivation depends more upon satisfactory horticultural practices than upon the type of soil alone.

Horticultural Factors—Nearly two-thirds of the acreage in the abandoned blocks was lost because of horticultural factors. Old age and the removal of trees interplanted with apples may be regarded as "natural" causes in contrast with general neglect and inadequate spraying which depend upon the grower. The term "general neglect" is used here to indicate neglect in pruning, cultivation and fertilizer practices, as well as in spraying, while the latter classification is applied to blocks of trees otherwise satisfactorily handled. The reasons usually given for general neglect include absentee ownership, frequent changes of tenants, too few trees to justify spraying equipment, fruit production a very minor farm enterprise, the discouragement of low fruit prices in recent years as well as of farm prices in general, and—though apparent rather than expressed—the personality of the grower. The spraying may have been ineffective because of too few applications, incorrect timing, lack of thorough coverage of the trees, or various combinations of those causes. In most instances both general neglect and inadequate spraying resulted in severe damage from leaf spot which thus became the most important single immediate cause of the abandonment or removal of these 250 blocks of trees. When the losses of blocks of

Table 2. Ages at which 40 blocks of cherry trees died or were removed and the range in ages of 1,455 scattered trees lost from old age in 16 different blocks.

Abandoned Blocks*						Scattered Trees		
Exact Age When Lost	No. of Blocks	Age Range When Lost	No. of Blocks	Min. Age When Lost	No. of Blocks	Age Range When Lost	No. of Blocks Incl.	No. of Trees
17	1	17-25	1	Over 18	1	18-26	2	250
19	1	18-26	1	Over 20	1	20-28	1	10
23	1	20-26	1	Over 22	1	20-38	1	530
25	1	20-28	2	Over 25	3	21-29	1	100
27	2	23-31	1	Over 30	2	22-30	2	195
28	3	25-30	3			25-33	3	133
29	2	25-32	1			30-38	4	112
30	1	25-33	1			40-48	2	125
31	1	26-33	1					
33	1	30-36	2					
36	1	30-37	1					
38	1	30-38	1					
	16		16		8		16	1455

*Approximately 9,800 trees in these 40 blocks.

trees were attributed to the joint action of two or more of the horticultural factors, the more frequent combinations were old age and general neglect and old age and inadequate spraying.

As indicated in Table 1 there were 40 blocks of trees which had died or had been removed since 1930 because of old age alone. In 16 instances the trees had died or been removed in a single year, in 16 other cases the trees had died out over a known period of years, while in the remaining 8 blocks the growers were only able to state that the trees had disappeared since 1930. The ages of the trees in these three classes are shown in the left portion of Table 2.

The second part of Table 2 indicates the range in ages of scattered trees lost in 16 blocks owing to old age alone, to which later reference will be made. The 25- to 30-year age group includes 40 per cent of the blocks lost from old age alone. Although the disappearance of all blocks included in Table 2 were attributed by the growers to old age alone, it may easily be that those listed at less than 20 years of age were also due to other factors as well, especially soil type.

Economic Factors—Only two of the 250 blocks of trees were removed solely because of low cherry prices since 1930. The predominant economic factor was the abandonment of the entire farm, either because it was absorbed in the growth of an adjacent town or by a resort development, as in Allegan County, or was in a submarginal farming location in the other counties.

Combinations of Factors—An eighth of the acreage of abandoned blocks was lost as the joint result of factors in two or more of the previously mentioned groups. The number of blocks of trees abandoned or lost from various combinations of factors in two or more of the groups listed in Table 1 were as follows:

Winter injury and general neglect	13
Poor site and general neglect	11
Winter injury and inadequate spraying	4
Old age, poor site and general neglect	2
Winter injury, old age and general neglect	1
Winter injury and rodents	1
Winter injury and mechanical injuries	1
Poor site and old age	1
Poor site and inadequate spraying	1
Poor site, general neglect and drought	1
	36

Unknown—It was impossible to account for the disappearance of two per cent of the acreage in these blocks of trees, either because no one was at the farm when visited, the inability of neighbors to account for it, the fact that the present tenants or owners had come to the farm since the trees were removed, or for other reasons.

Variations Between Counties—Figure 1 illustrates the considerable variations between the six counties in the relative importance of each of the above mentioned groups of factors, while Table 1 indicates the variations between the combined effects of these factors. In Berrien County 2.68 per cent of the commercial acreage of red cherries in 1930 had disappeared through death or removal of entire blocks of trees, 2.84 for Grand Traverse, 3.60 for Leelanau, 4.95 for Oceana, 9.21 for

Allegan, and 10.36 for Mason Counties. The extent of the mortality in the latter two counties is sufficiently greater than in the others to suggest that they are marginal for commercial cherry producing counties as a whole. Certain townships in each, however, are decidedly not marginal areas for cherry growing. Between 4 and 5 per cent of the red cherry trees of all ages present in the commercial orchards of these six counties in 1930 have since disappeared through the death or removal of entire blocks of trees. It should be mentioned that blocks of trees have been included in Table 1 and Fig. 1 when a few trees may still have been alive; but in such cases the remaining ones were either less than 5 per cent of the original number or were receiving no further care and were quite likely to be dead or removed in a year or two.

The Michigan Agricultural Experiment Station has published a number of bulletins designed to aid the cherry grower in reducing tree mortality, among which the following are still available in regard to specific topics; Michigan land type (6), selection of orchard sites (7), land types for fruit production (8), soil testing (9), management of sandy soils (10), soil erosion (11), maintaining cherry tree productivity (12), factors influencing cherry yields (13), pollination (14), spraying (15), and diagnosing orchard ills (16).

Mortality of Scattered Trees

Only part of the total tree mortality is represented by the trees lost through the disappearance of entire blocks. A larger part of the total consists of scattered trees throughout the still existing blocks which have been removed for various reasons. Such losses may or may not have been replanted, but the block as a whole continues in production. In order to obtain a sample of this form of tree mortality a record of the number of trees lost since 1930 was obtained from 20 growers in each of the six counties[1] who operated a total of 295 blocks of trees which had contained 126,717 trees in 1930.

The tree mortality data obtained from a total of 120 growers in six counties are summarized in Table 3.

It is significant to note that while the percentage of trees lost in this manner is rather uniform in the six counties with an average of 10 per cent, the proportion of those tree losses that were replaced varied from 6 per cent in Mason County to 52 per cent in Grand Traverse County, with an average of 32 per cent. The sample is either too small to establish the trend of tree mortality according to age or it may be impossible to determine it in this way since the joint effects of climatic, soil, and cultural factors may offset the tendency for older trees to have a higher mortality rate, the expected situation when factors other than age are the same. The scattered trees now missing in nearly all blocks had been lost over a period of years and the range in the ages of trees lost from old age alone was presented in Table 2. As in the case of entire blocks of trees removed because of old age, the mortality was largely among trees 25 years of age or older.

[1]Berrien: 34 blocks in Hagar, Bainbridge and Pipestone townships.
Allegan: 38 blocks in Ganges and Casco townships.
Oceana: 45 blocks in Hart and Shelby townships.
Mason: 42 blocks in Summit and Riverton townships.
Leelanau: 55 blocks in Leelanau, Sutton's Bay, Bingham, and Elmwood townships.
Grand Traverse: 81 blocks in Peninsular and Garfield townships.

Table 3. Summary of scattered tree mortality in 295 existing blocks operated by 20 growers in each of six Michigan Counties, 1930 to 1938.

Year Set	Age in 1930	Age in 1938	Berrien			Allegan			Oceana			Mason			Leelanau			Grand Traverse			Totals			Per Cent Lost	Per Cent of Loss Reset
			Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset	Trees in 1930	Trees Lost	Trees Reset		
1900	30	38	—	—	—	—	—	—	115	70	—	625	112	100	—	—	—	—	—	—	740	182	100	24.6	54.9
1901	29	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1902	28	36	—	—	—	—	—	—	50	10	—	—	—	—	—	—	—	—	—	—	50	10	—	20.0	—
1903	27	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1904	26	34	—	—	—	—	—	—	—	—	—	175	29	5	—	—	—	—	—	—	175	20	5	11.4	25.0
1905	25	33	10	—	—	185	93	15	700	50	25	—	—	—	—	—	—	—	—	—	895	143	40	16.0	28.0
1906	24	32	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—
1907	23	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	215	—	—	215	—	—	—	—
1908	22	30	100	70	—	—	—	—	—	—	—	—	—	—	—	—	—	1000	325	—	1100	395	—	35 9	—
1909	21	29	—	—	—	—	—	—	290	235	—	—	—	—	—	—	—	750	450	300	1040	685	300	65 9	43.8
1910	20	28	95	23	20	—	—	—	2000	220	70	290	10	—	2750	100	—	1100	310	225	6235	663	315	10.6	47.5
1911	19	27	—	—	—	—	—	—	—	—	—	200	10	—	3300	500	—	960	200	—	4460	710	—	15.9	—
1912	18	26	475	37	—	25	12	—	200	22	—	112	5	—	—	12	—	977	350	125	1789	438	125	24.5	28.5
1913	17	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	300	1	1	300	1	1	.3	100.0
1914	16	24	—	—	—	—	—	—	—	—	—	150	5	—	—	—	—	—	—	—	150	5	—	.3	—
1915	15	23	—	—	—	190	15	—	600	60	30	245	10	—	—	—	—	—	—	—	1035	85	30	8.2	35.3
1916	14	22	—	—	—	—	—	—	—	—	—	—	—	—	400	250	—	845	100	100	1245	350	100	28.1	28.6
1917	13	21	—	—	—	—	—	—	—	—	—	—	—	—	1100	450	—	—	—	—	1100	450	—	40 9	—
1918	12	20	162	14	8	200	20	—	—	—	—	550	60	—	4300	360	35	1622	147	145	6334	601	188	8 8	31.3
1919	11	19	50	5	—	395	30	28	280	5	5	—	—	—	2000	50	30	—	—	—	2725	90	63	3.3	70 0
1920	10	18	—	—	—	1200	75	35	1650	150	150	250	10	—	2900	350	—	800	160	50	6800	745	235	11.0	31.5
1921	9	17	634	60	—	839	37	10	—	—	—	—	—	—	1700	250	40	390	5	5	3554	352	55	9 9	15.6
1922	8	16	186	36	—	484	55	50	600	30	5	—	—	—	6350	995	35	2118	604	102	9738	1720	192	17.7	11.2
1923	7	15	—	—	—	220	10	10	300	5	5	650	15	—	5299	135	95	3165	215	215	9634	380	325	3 9	85 5
1924	6	14	—	—	—	180	25	15	2616	80	50	475	8	5	4835	375	10	1618	83	40	9724	571	120	5.9	21 0
1925	5	13	419	24	8	580	27	—	2350	65	—	1140	30	—	2675	77	12	450	10	—	7614	233	20	3 1	8.6
1926	4	12	20	—	—	81	8	—	7258	484	296	1375	282	250	2695	55	15	2293	134	133	13727	963	693	7.0	72.0
1927	3	11	289	39	—	797	32	21	2596	280	255	1430	172	105	1200	26	11	5354	148	122	12156	695	514	5 7	74 0
1928	2	10	302	67	—	440	22	6	560	20	10	—	—	—	9925	1115	280	2810	92	75	14037	1316	371	9 4	28 2
1929	1	9	120	6	6	672	42	17	550	6	6	655	75	—	920	95	10	3097	117	95	6014	341	134	5.7	39 3
1930	0	8	150	3	—	295	15	—	—	—	—	—	—	—	1850	145	—	1320	109	102	3615	272	102	7.5	37.5
Totals			3018	384	42	6774	518	207	22715	1792	907	8322	824	465	54199	5340	573	31689	3558	1834	126717	12416	4028	9.8	32.4
									8	—	—	10	—	—	10	—	—	11	—	—	10	—	—	—	—
Per Cent Lost			13	—	—	8	—	—	51	—	—	6	—	—	11	—	—	52	—	—	32	—	—	—	—
Per Cent of Loss Reset			11	—	—	40	—	—																	

Table 4. Comparative importance of causes of the scattered tree mortality in 295 existing blocks operated by 20 growers in each of six Michigan counties, 1930 to 1938.

Causes	Number of Trees Lost						
	Berrien	Allegan	Oceana	Mason	Leelanau	Grand Traverse	Six Counties
Winter injury	—	—	117	5	50	217	389
Unfavorable soil	95	20	85	—	—	620	820
Old age	70	73	130	147	100	935	1,455
Inadequate spraying	22	—	295	375	1,200	—	1,892
Combinations and Misc.*	197	425	1,165	297	3,990	1,786	7,860
Total	384	518	1,792	824	5,340	3,558	12,416

Causes	Percentages						
	Berrien	Allegan	Oceana	Mason	Leelanau	Grand Traverse	Six Counties
Winter injury	—	—	6	*	1	6	3
Unfavorable soil	25	4	5	—	—	17	7
Old Age	18	14	7	18	2	26	12
Inadequate spraying	6	—	16	46	22	—	15
Combinations and Misc.*	51	82	66	36	75	51	63
Total	100	100	100	100	100	100	100

*Miscellaneous includes: Wind, snow and ice, drouth, frosty location, erosion, excess fertilizer too close to roots, poor nursery stock, replacement of Early Richmond variety, blackheart, mushroom root "pin hole" borers, rodents, and mechanical injuries during cultivation and harvesting.

The number and proportion of tree losses attributed to the various causes is presented in Table 4.

Except in Mason County the largest proportion of the scattered tree mortality was the result of several factors. This part of the mortality in Table 4 includes trees lost by the combined effect of two or more causes and those lost by single factors, some being lost through winter injury, some by unfavorable soil, some by inadequate spraying or by a miscellaneous cause. In such instances the growers were frequently unable to recall the number of trees lost from each cause separately, necessitating the final classification used in Table 4.

Total Tree Mortality

Data obtained in these six counties (an 80 per cent sample of the commercial cherry orchards in the 11 important cherry counties of Michigan) show that approximately 15 per cent of the red cherry trees in these orchards in 1930 have been lost since then, 5 per cent by the death or removal of entire blocks and 10 per cent through the loss of scattered trees in blocks that are still in production. Since nearly a third of the loss of scattered trees was replaced, the net mortality in blocks existing in 1930 in the six counties amounts to 12 per cent. The figure of 10 per cent mortality for scattered trees is conservative, because the records were obtained in the more intensively planted town-

ships and the orchards in general were noticeably better managed on the whole than those in the townships with only a comparatively few cherry orchards. Although based entirely on general impressions gained while making the study, it seemed to the writer that the mortality of scattered trees in the latter townships was at least a third greater than in the townships with many cherry plantings. Should later studies of mortality in these more marginal areas bear out that impression, it would mean that during the period in question a given number of cherry trees has decreased at not to exceed 4 per cent per year. On account of the rapid expansion of the cherry industry in Michigan between 1920 and 1930 and a much slower growth since 1930, the average age of trees in 1938 is undoubtedly somewhat greater than several years ago. As the number of trees become more stabilized a somewhat greater annual mortality may be expected. Nevertheless, this study shows that under average climatic and soil conditions and with average care the sour cherry orchard is a long-lived enterprise. Furthermore, tree mortality could be substantially reduced by better care, particularly better spraying to reduce leaf spot attack and the winter injury that often follows in its wake.

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RELATION OF HIGH OCTOBER TEMPERATURES TO RATE OF RIPENING OF APPLES HELD IN AIR-COOLED STORAGES

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One cannot predict the temperatures that will be recorded between the time this paper is being written (October 19) and the date it will reach its readers. Regardless of weather trends subsequent to the time of this writing, however, the record-breaking temperatures that prevailed between October 10 and October 19 will make this season one of the most unfavorable for the operation of air-cooled storages that the apple industry of this region has experienced in the 15 years that the writer has been associated with the study of these storages. It therefore appears advisable to warn owners of air-cooled storages that apples held in common or air-cooled storages may be expected to ripen considerably in advance of the normal dates and must be merchandised earlier if they are to reach the consumer in prime condition.

Practically all apples that are being held in common storage this season were harvested between September 15 and October 15. The mean daily outdoor temperature at East Lansing for the latter half of September averaged about three degrees below the normal daily means. The daily maxima, however, were slightly higher than the normal daily maximum temperatures, so it would appear that most operators of air-cooled storages should have attained what might be termed a normal storage room temperature by October 1, or fruit temperature reading of 48° to 50° F.

During the first nine days of October there were only three days at East Lansing when the mean temperatures were above the normal. A minimum temperature of 28° was recorded on the morning of October 7. The mean daily temperatures for this period averaged approximately two and one-half degrees below the normal, though again, the daily maximum temperatures were higher than normal. On the whole, it would appear that air-cooled storages should have afforded approximately normal seasonal temperatures up to October 9.

The mean daily temperatures during the next 10 days (October 10 to 19, inclusive) exceeded the normal means by 6 to 19° and a maximum of 85° was recorded on October 16. The average mean daily temperatures during this period exceeded the normal by approximately 13°.

Earlier investigations of this experiment station have shown that the average fruit temperature in a properly managed air-cooled storage should be about four degrees lower than the average daily mean temperatures. In other words, if these storage rooms were being loaded between October 10 and 19 and were managed in the usual manner, one would expect a fruit temperature of approximately 60° on October 19. If the loading had been completed by October 10 and the storage had been tightly closed throughout the period of excessively high temperatures, the temperature of the apples might be less than 50°. Observations made October 14 and 15 showed temperatures ranging from about 45° in one storage where the loading was completed early to as high as 58° where much loading was done during the week of October 10.

It is well known that the rate of ripening at 50° is two times the rate at 40°, and that apples ripen twice as rapidly at 65° as at 50°. It is then apparent that apples held in air-cooled storages were ripening approximately twice as rapidly during the second 10 days of October 1938, as in normal years. Ten days under such conditions would result in as much ripening as would occur in three weeks in a normal season, even if it were possible to reduce immediately the temperature of the apples on October 20 to approximately 44°. This is impossible in a storage where the operator is depending on natural or fan-driven air-flow through the storage room for cooling.

The most optimistic guess of the writer, based on theoretical considerations, is that most operators of air-cooled storages should plan to merchandise each variety at least one month earlier than has been the practice in what might be termed normal years. A few growers who managed to keep well-insulated storages closed during the very hot weather may find that these apples will keep nearly as well as they have kept in the average year.

Calendar dates cannot be relied upon entirely in determining when the fruits should be marketed. The ground color changes should be watched carefully and the rate of softening may be of some value as an index of degree of ripeness. Perhaps the best criterion as to the time of marketing is based upon the condition of fruits after removal from the storage room to the kitchen or living room for a week, for this is essentially the treatment most of the apples will be subjected to before consumption. When fruits tend to become mealy or show a loss of quality due to over-ripeness when held for a week at living room temperatures, they should be moved immediately, for it is claimed by many experienced men that attempts to force over-ripe apples having poor quality on the consumer is diverting consumer choice from apples to citrus fruits.

THE RUBBER TIRED FARM WAGON

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Application and Use

The application of pneumatic tires to tractors and more recently, to a number of field machines has demonstrated beyond doubt a greater efficiency as related to rolling resistance than is possible with the conventional steel wheel. As a result, many farmers have converted their farm wagons or have built wagons of automobile and truck parts to place them on pneumatic tires. Many inquires have been received by Michigan State College for plans to assist farmers in making these conversions. This article was therefore designed to make available such plans as we believe were worthy of reproduction.

Several farms in the vicinity of the College were visited to locate if possible, types of farm wagons that could be recommended. Unfortunately, these wagons were not entirely satisfactory and for the most part were in the process of rebuilding. The plans shown are adaptations of automotive parts to farm wagon construction made by Jack Mac Allan, the College blacksmith, who has done much work on this problem.

Use of Photographs

Photographs* are used in the preparation of this article because it is believed that they are more understandable than the conventional type of plans. The photographic cuts include complete assembly views of three wagons. Figures 1 to 5, inclusive, represent a conventional farm wagon converted on rubber tires. Figures 9 to 16, inclusive, represent a wagon built up of two front axles of an automobile and a special chassis construction. Figures 6 to 8, inclusive, represent a modification of the second wagon, as can be readily identified.

Description of Wagons

The Conventional Farm Wagon Converted on Rubber Tires

This construction as indicated by figures 1 to 5, inclusive, represents the simplest change known. The wagon shown in Fig. 1, is essentially the same as the conventional farm wagon, except that axle skeins have been removed, and the axles have been cut away to fit the contour of the two Chevrolet's front axles as shown at 4A and 5A representing axle attachments.

The steel axles are attached to the wooden axles by means of U-bolts. Note U-bolts in figures 3B and 4B for front and rear axles respectively. For front axle, the U-bolts pass over sand board through the fore-

*Photographs were prepared by Floyd Linebaugh of the Agricultural Engineering Department.

hound, along side of the wooden axle and fasten at the spring supports of the steel axle. The fastening of the steel axle is similar at the rear end except that U-bolts pass between the rear bolster and the false bolster as shown in Figure 4B. Note the location of brace irons as found in the following figures: 1C, 2C, 4C, and 5C. The braces are made of ½" x 1½" flat stock.

The wheel spindle is fastened firmly to the axle by means of two pieces of angle iron, one of which is shown in detail in figures 5D and at 16A. The spacing of the drilled holes can be readily determined. All four wheel spindles are attached in this manner to the axle because they must be rigid. There will be a slight camber or tilting of the wheels from the vertical, but this condition is not objectionable.

A suggested order of procedure follows:

(1) Obtain two front axles with spindles and wheels from a 1928 Chevrolet car chassis.
(2) Dismantle the farm wagon to have access to the wooden axles for cutting and trimming.
(3) Remove skeins from axle.
(4) Cut and trim wooden axle to fit the contour of the steel axle.
(5) With the wheels assembled to the Chevrolet axle, adjust so that wheels are parallel or in line, and in this position spot weld the spindle to the axle, to maintain proper alignment.
(6) Obtain enough 1½" angle iron to make eight pieces to serve as clamps for the axle spindle.
(7) Cut angle iron to proper length, drill to match holes and assemble to form a rigid lock of spindle to axle.
(8) Forge four U-bolts for front and rear axles and assemble parts.
(9) Measure length of braces needed, drill and assemble as indicated in figures 1 to 5 inclusive.
(10) Reassemble the wagon.

A Built-up Wagon Using Car Front Axles, and Fabricated Chassis Construction

This construction deals essentially with two 1928 Chevrolet front axles inverted as shown in figure 9 at A. The front axle in the wagon assembly is turned over to bring the steering arm tie rod in front so that fastening to tongue is made possible. The front bolster is made from a steel eye beam of three-inch depth. The front bolster stakes are likewise eye beam construction, set into the webs of the bolster eye beam and welded to a plate attached to axle as shown in Fig. 13A. Figure 13 at B represents a false bolster not shown in the assembly. The rear bolster stakes are made from ½" x 1" flat stock welded to axle as shown in 9B and 10B. The wagon reach is made of two-inch iron pipe and extends from front axle to a short distance back of the rear axle as indicated in Fig. 9C.

The reach is free to slide into the journal as shown in figures 9D and 14D. This journal is made of a piece of 2½" pipe welded to axle by means of a clamp.

The sleeve as shown in figures 9E and 11A is made of 2½" pipe and likewise is free to turn and slide on the reach proper. The wagon wheel base is regulated and clamped into position by the two collars as shown

in Fig. 11 at B. The braces to rear axle are welded to sleeve 11A as shown in Fig. 11 at D and at the other end the braces are bolted to axle at the spring support flanges as shown in Fig. 10 at C.

The rear wheel spindles are clamped to axle in exactly the same manner as with the first wagon.

The front wheels are attached through the spindle arms to the tie rod in the conventional manner used on automobiles as shown in Fig. 9.

It will be necessary to bend the spindle steering arms toward the wheels in order that the wheels will have proper angles for turning. The tie rod must be lengthened to accommodate this change.

The braces from reach to front axle are shown in figures 12 and 15. Figures 12, 14, and 15 represent views taken from underneath the chassis in order to show method of attachment.

Hitch

The hitch for this wagon is shown in figures 8, 9, and 15. Figure 15, previously mentioned, is photographed from underneath and should not be confused with the other two views. Figure 8 shows the hitch in close-up.

The pivot point of hitch is shown just in front of axle at point (A) through U-iron (B) which is welded to the axle. This U-iron extends back of the front axle, and provides an attachment for the reach which is shown at (A) in Fig. 7. Over and below the U-iron are two plates which are welded to the hitch proper at point C not clearly shown because of position of tie rod, (D). These plates serve as a pivot point as shown at (A) in Fig. 8.

The tongue is attached to the hitch as shown at (E) in Fig. 8.

The U-bar (F) supporting the tongue is reinforced by a U-bar G. Bolt (H) is welded to U-Bar, and provides an attachment for the rod through the slotted block (I). This slotted block is welded to tie rod and provides free motion of tie rod in accomplishing steering. The front U-bar (J) is used as a guide for the tongue, which enables backing up when used with horses, providing a stop and preventing jackknifing.

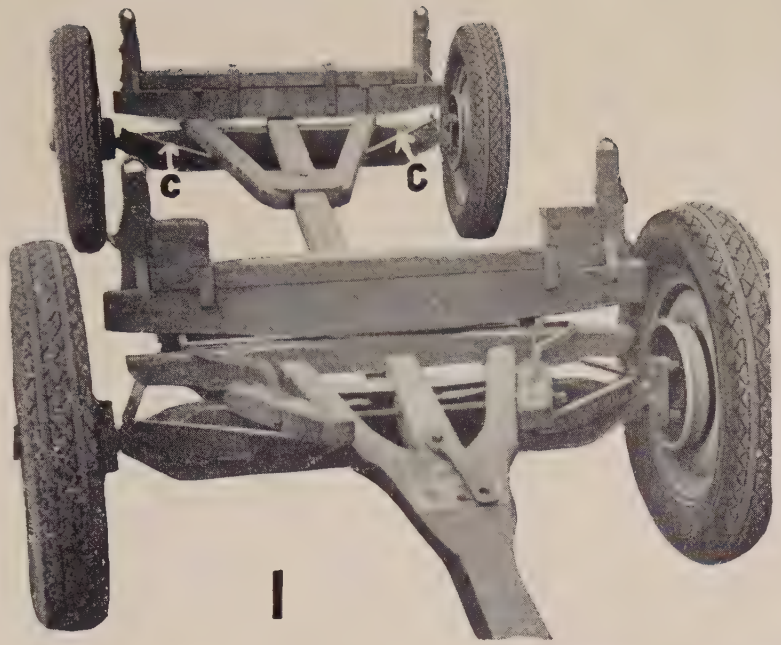
A Modification of Wagon No. 2

This wagon differs from the wagon just described in the axle construction as shown in figures 6, 7, and 8. It will be recognized that the axles are set in the normal position rather than inverted and uses eye-beam bolster construction. This construction is clearly shown in Fig. 7 which is a rear view of the front axle.

The rear axle bolster construction is identically the same as the front axle as shown in Fig. 6. The hitch and reach construction have been covered in the description of the second wagon.

Conclusion

It is expected that many new ideas will bring about improvements in the plans suggested. The wagons described in this article have been built and used on the College farm, and may be reproduced with confidence in the outcome. Suggestions on other combinations and simple devices are welcomed.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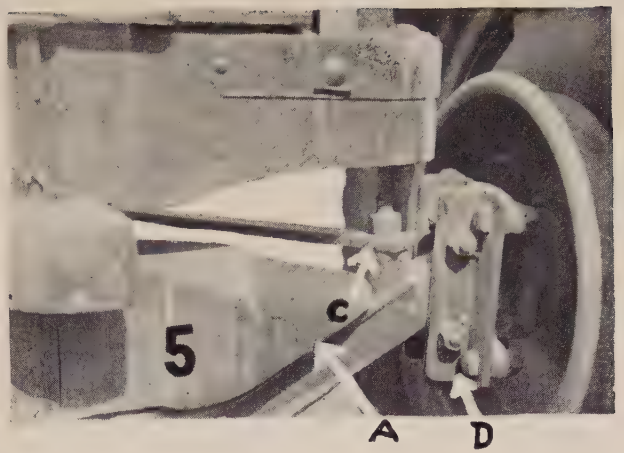
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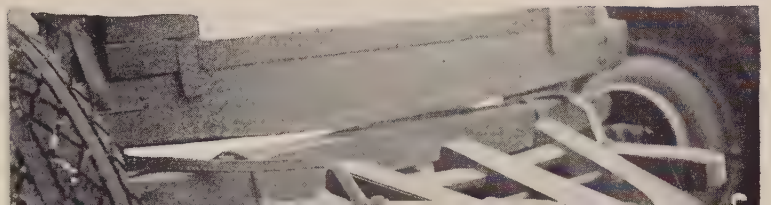
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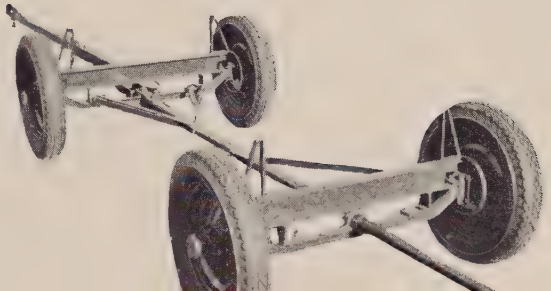

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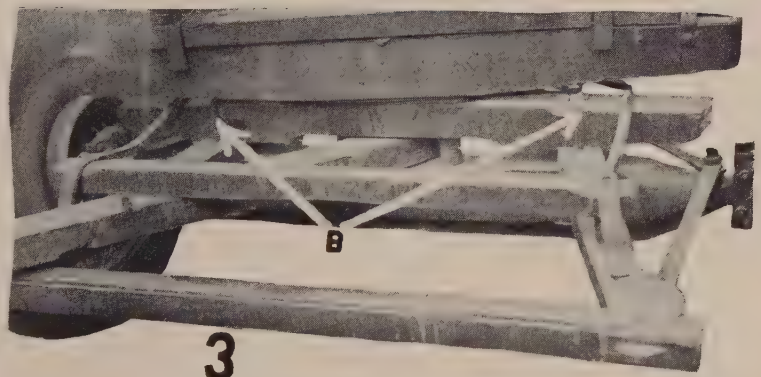

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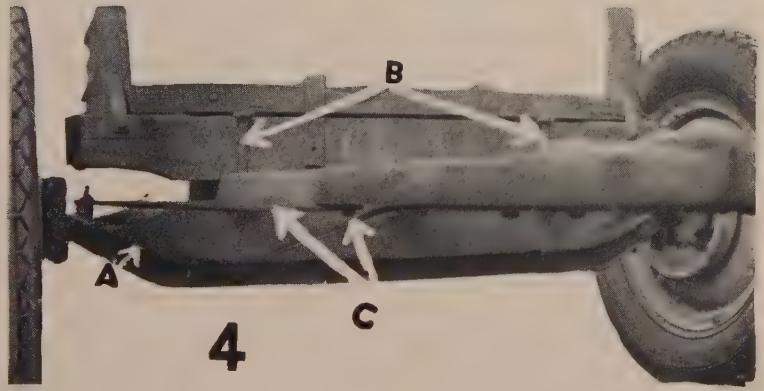

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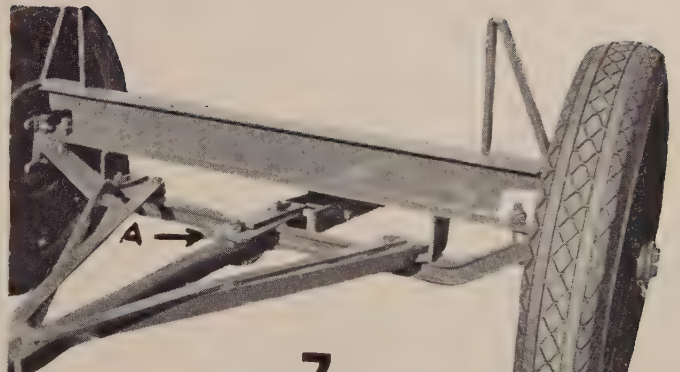

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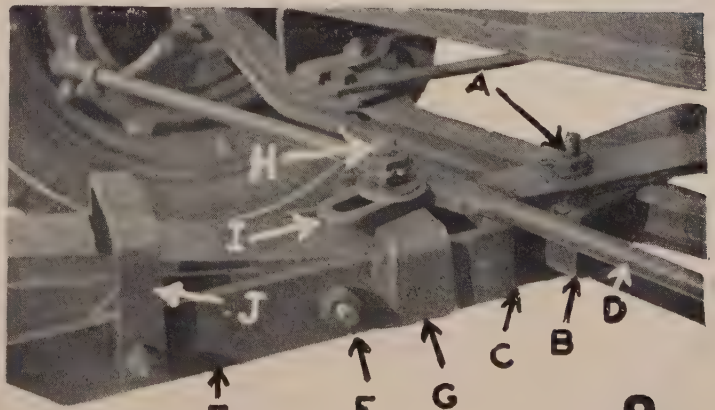

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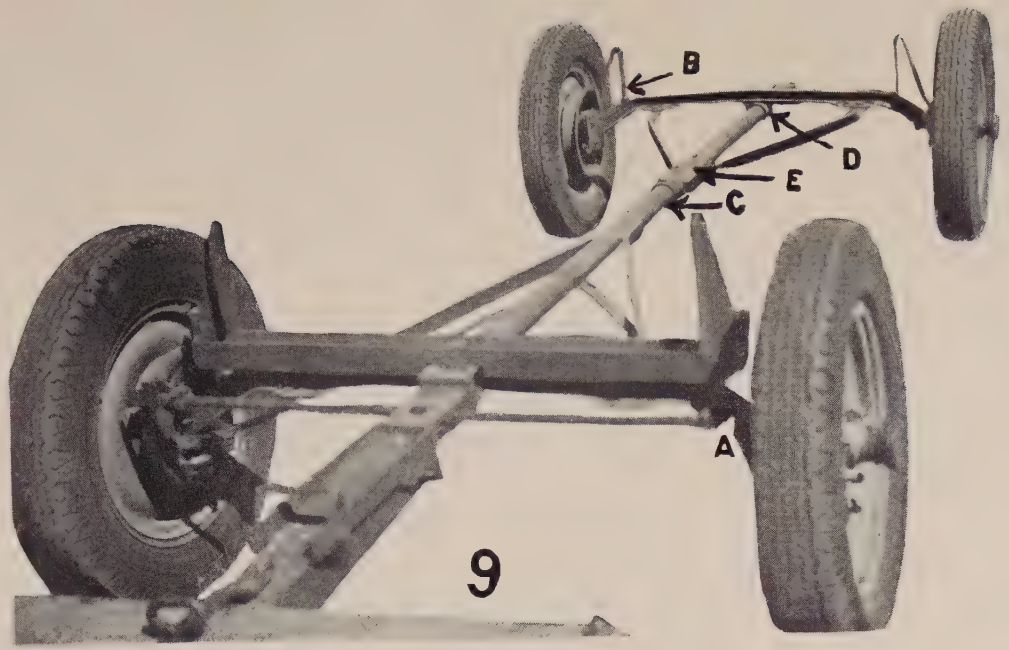

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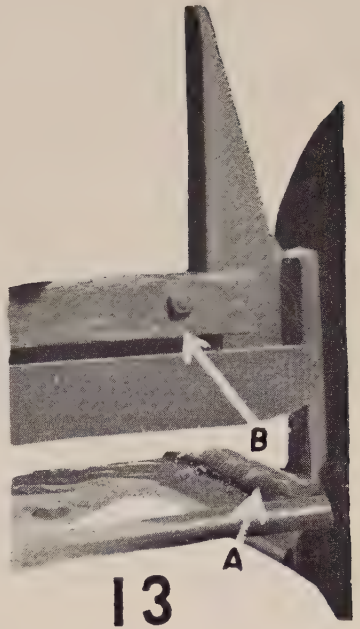

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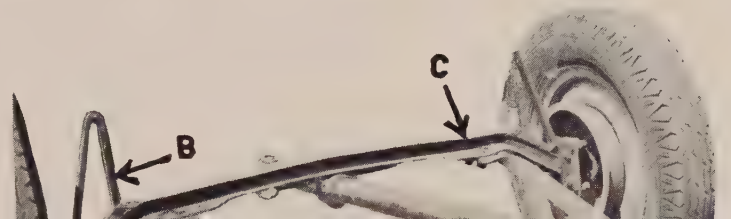

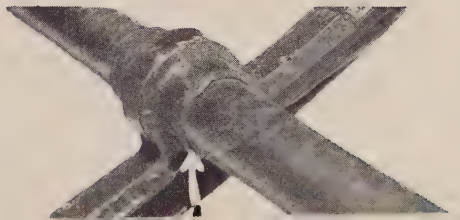

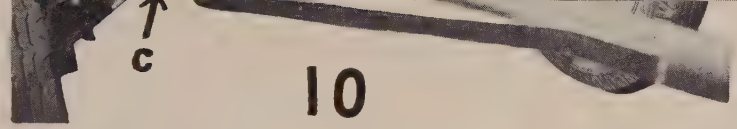

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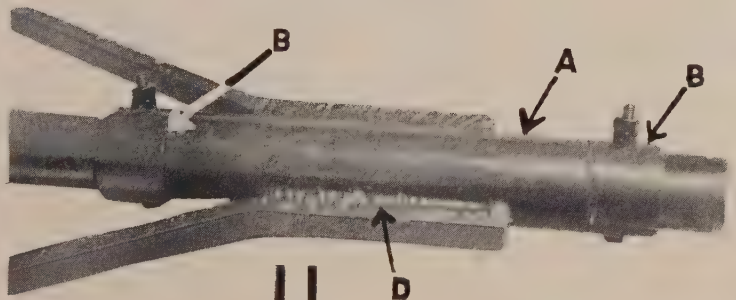

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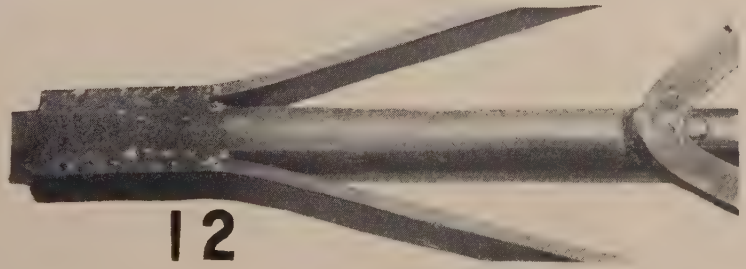

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THE POTASH SITUATION IN MICHIGAN ORCHARD SOILS

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Section of Horticulture

Potash is essential for the normal growth and development of plants, and fruit trees are no exception to this general rule. They require potash to manufacture the carbohydrates, proteins and fats which are necessary to produce the new tissues in the roots, shoots, leaves, and fruits. Without potash, nitrogen in the soil and that applied to the tree in the various forms of nitrogenous fertilizers is not fully utilized by the tree. A lack of potash might therefore be expected to reduce length and diameter growth. Soils contain potash in different amounts, according to their origin and previous treatment, and vary considerably in their power to release the potash that they do contain. Plants themselves vary in their power to absorb this potash from the soil and in their reaction to it. Although fruit trees will grow in soils which vary considerably in composition, their performance is necessarily closely associated with the nature and composition of the soil in which they are growing. Though potash is only one of a number of the materials which plants take in from the soil, its presence in adequate amounts is necessary for maximum fertility and crop production.

In order to study the relationship between fruit tree performance and available potash supply in the soil, various projects were set up during the period from 1934 to 1937. These projects consisted of (1) fertilizer treatments in a number of commercial orchards throughout the fruit growing areas of Michigan, covering a representative range of soils and varieties, (2) pot experiments at East Lansing, where soil and moisture conditions were controlled, and (3) a survey of orchards made in the fall of 1937 to determine whether potash is a limiting factor in fruit tree growth and production.

Field Experiments

The field experimental plots were laid out in 1934 in conjunction with comparisons of Cyanamid, sulphate of ammonia, and superphosphate fertilizers. Observations were made on tree performance during the 1935, 1936 and 1937 seasons, after which the project was terminated.

Apple, cherry and peach orchards were selected to represent the typical soil types and climatic regions associated with commercial fruit growing in Michigan. In the southwest section of the State, in Berrien, Van Buren, and Allegan counties, there were four peach, one apple and three cherry orchards under observation. These were growing on sandy to sandy loam soils. In Mason and Oceana counties, situated on the west coast of the state, about the middle of the lower peninsula, were three cherry and one apple orchard in the project. These orchards were all growing on sandy soils. Towards the north end of

the lower peninsula, in Grand Traverse county, there were three cherry orchards, all growing on a sandy to sandy loam soil. Thus there were a total of two apple, four peach, and nine cherry orchards under observation.

The basic plan for applying the various fertilizers may best be shown diagramatically in Fig. 1.

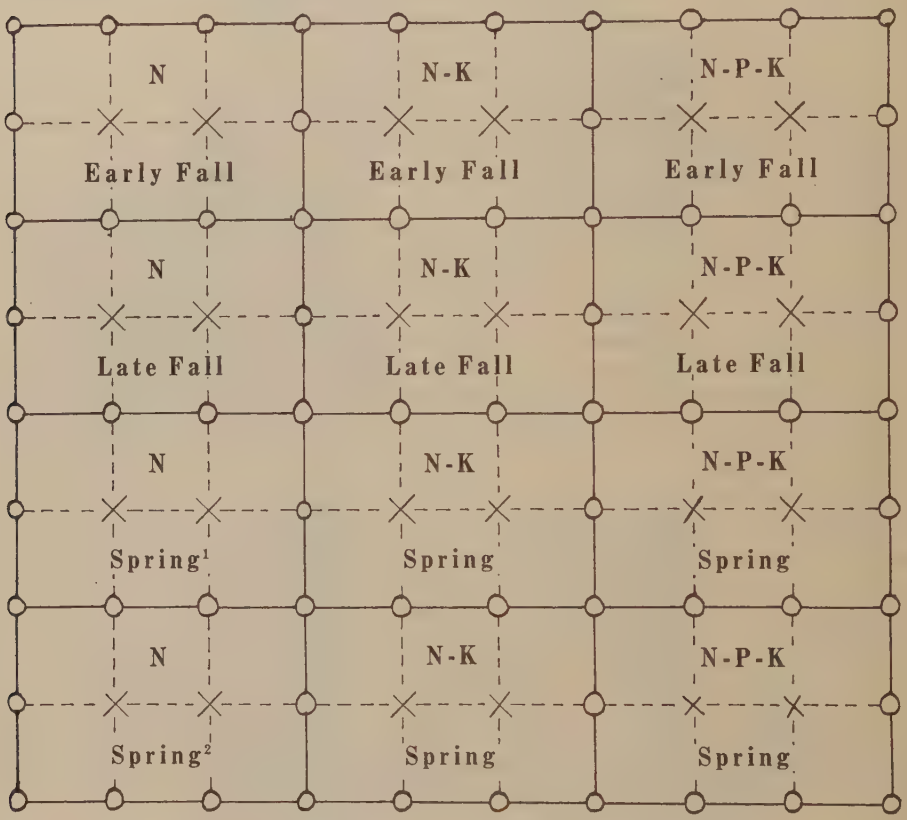

Fig. 1. Basic plan for fertilizer applications.

[1]Sulphate of ammonia as the nitrogenous fertilizer.
[2]Cyanamid as the nitrogenous fertilizer.

The solid lines show the extent of each plot. The crosses indicate the treated trees and the circles indicate the buffer trees between each treatment. A deviation from the usual practice of applying fertilizer in a ring consisted in applying it in squares adjacent to the treated tree. The dotted lines indicate the extent of these squares. Thus, in each treatment, consisting of two trees, there would be six separate applications corresponding to the six adjacent squares. This method eliminated any possibility of a double application where two rings might overlap and ensured an even distribution of the fertilizer. According to this method any fertilizer which might not be utilized by the tree

roots would be taken up by the cover crop roots, thus helping to build up the organic matter of the soil and indirectly benefit the tree. The various fertilizer applications were made at different times of the year for comparative purposes. The basic rates of application were as follows: nitrogen, 250 pounds per acre of either Cyanamid or sulphate of ammonia; potash, 100 or 200 pounds per acre of muriate of potash, depending on the nature and age of trees; superphosphate, 150 or 300 pounds per acre, also depending on the nature and age of trees. The early fall applications were made around the middle of September, the late fall applications a month later, and the spring applications towards the end of March or early April for Cyanamid, and about two weeks later for sulphate of ammonia.

In order to study the changes in potash content of the soil, soil samples were tested for available potash at the beginning of the experiment in 1934, and at monthly intervals throughout the growing seasons of 1936 and 1937. The orchards from which these soil samples were taken were chosen so as to give as wide a range of soil and fruit tree variety as possible and still keep the number low enough for practical consideration. The trees in these orchards were comparatively uniform from the standpoint of vigor and thrift. The results from these tests show that, though there was a slight increase in amount of available potash in both treated and untreated plots, this increase was insignificant, plots testing 0-10 pounds per acre available potash at the beginning of the experiment and 0-20 pounds per acre at the end of the project. This lack of measurable increase in the available potash content of the soil following potash application is probably due to the high fixing power of these soils.

The effect of potash on the condition and vigor of the trees was studied by making monthly observations on the general color and health of the foliage. Since it has been suggested by some investigators that potash may prevent some of the burning which often occurs when Cyanamid is applied late in the spring, special care was taken to observe any reduction of injury following the use of potash with Cyanamid. There was a certain amount of foliage injury in 1936 due to late spring Cyanamid applications, but the addition of potash to those plots receiving Cyanamid did not prevent or alleviate this burning of the foliage, except in one case. What appeared to be a slight benefit from the use of potash in this one case may have been due to the better condition of the trees at the beginning of the experiment rather than the result of any potash application. Trees receiving potash were not any more vigorous and did not carry any greener or healthier foliage than did trees not receiving this fertilizer.

From the results obtained over this three-year period, it can be stated that potash under the conditions of these investigations has not been beneficial to apple, cherry or peach trees in any way that could be observed, though the possibility of a long time effect which may develop following the continued use of this fertilizer is recognized.

Pot Experiments at East Lansing

In order to study the effect of potash on fruit trees grown under controlled soil and moisture conditions, two separate experiments were conducted. As in the field experiments, these pot experiments

were run in conjunction with Cyanamid trials. The first of these two-pot experiments consisted of one-year-old Montmorency cherry trees grown in three different soil types in wooden tubs. The trees were grown for a year in the tubs and then given the various fertilizer treatments in 1936 and 1937. Although kept outdoors, the soil in which these trees were grown was covered so as to maintain it at a definite moisture content. The second of these pot experiments was conducted on one-year-old Montmorency cherry trees, all grown in sandy soil contained in galvanized iron cans. They were planted in the early part of January 1937, after having been subjected to cold weather in order to break the rest period, and then grown in the greenhouse during the period of the experiment.

For convenience, the first of these pot experiments will be called the Tub Experiment and the second the Greenhouse Experiment.

Tub Experiment

There were 150 trees in this experiment, each grown in a separate tub. Fifty of these trees were grown in a sandy soil, 50 in a sandy loam soil, and 50 in a loam soil. In 1936, each group of 50 trees was divided so that half of these were grown in a soil maintained at a low moisture content, and half in a soil maintained at a high moisture content. The actual percentages varied according to the type of soil. For sand these were 4.2 and 14.8, for sandy loam 6.3 and 17.0, and for loam 10.4 and 25.6%. In each group of 25 trees, the following treatments were given:

1.	Cyanamid at rate of 700 lbs. per acre plus potash at rate of 200 lbs./A..	5 trees
2.	Cyanamid at rate of 300 lbs. per acre plus potash at rate of 200 lbs./A..	5 trees
3.	Cyanamid at rate of 700 lbs. per acre	5 trees
4.	Cyanamid at rate of 300 lbs. per acre	5 trees
5.	Check—no fertilizer	5 trees
		25

In 1937, the treatments were somewhat modified in order to compare nitrate of soda and sulphate of ammonia with Cyanamid, each with and without potash. The variations in high and low moisture were discontinued so as to permit this treatment to be carried out. It was thought that more valuable information could be obtained on the potash-nitrogen relationship by making such a change than by continuing the project as originally outlined.

Results

1936—The effect of the various treatments was determined in several different ways. Total twig growth was measured at the end of the growing season. Notes on foliage conditions were made during the year. When it was seen that certain treatments were causing injury, the extent of such injury was determined by making leaf counts on all trees and by measuring the secondary growth stimulated by this defoliation.

Considering total twig growth in the different soil types, the greatest growth in sand and sandy loam soil was obtained with Cyanamid at the rate of 300 pounds per acre at a high moisture content. When potash was added to the high rate Cyanamid application in high and

low moisture sandy soils, there was a slight increase in growth. In all other comparisons trees receiving potash made less growth than those not so treated. In loam soils, the greatest total growth was obtained with Cyanamid at the rate of 700 pounds per acre in both high and low moisture soil. Again, trees grown without potash made better growth than those grown with this fertilizer, with one exception, when potash was added to Cyanamid at the rate of 300 pounds per acre in a low moisture treatment.

Considering all treatments, the greatest total growth was made in the loam soil and the least in sand, and trees without potash made better growth than those with potash. This detrimental effect of potash was more pronounced under high than under low moisture conditions.

Table 1. Secondary growth in tub experiment 1936.

Treatment	Soil					
	Sand		Sandy Loam		Loam	
	Growth in cms. per tree	No. growing points per tree	Growth in cms. per tree	No. growing points per tree	Growth in cms. per tree	No. growing points per tree
High Moisture:						
700 lbs. Cy \ 200 lbs. KCl /	56.9	14.6	12.6	3.2	—	—
300 lbs. Cy \ 200 lbs. KCl /	—	—	—	—	—	—
700 lbs. Cy	43.0	7.2	—	—	—	—
300 lbs. Cy	—	—	—	—	—	—
Check	—	—	—	—	—	—
Low Moisture:						
700 lbs. Cy \ 200 lbs. KCl /	18.2	4.8	1.6	0.6	—	—
300 lbs. Cy \ 200 lbs. KCl /	—	—	—	—	—	—
700 lbs. Cy	14.3	3.0	—	—	—	—
300 lbs. Cy	—	—	—	—	—	—
Check	—	—	—	—	—	—

With respect to injury from the use of Cyanamid shown in Table 1, the following observations were made:

Trees receiving Cyanamid at rate of 700 pounds per acre, with or without potash, produced most "secondary growth" in sandy soils with a high moisture content and less in the same soil with a low moisture content. Again, in the sandy loam soil, trees receiving Cyanamid at the rate of 700 pounds per acre plus potash produced some secondary growth in the high moisture treatments and only a slight amount in the low moisture treatment. No secondary growth was made in any of the other treatments in the experiment.

The greater secondary growth associated with high moisture may be explained by the fact that at the beginning of the experiment, the tubs were allowed to become too dry, facilitating the formation of dicyanodiamide. Subsequent excess watering would carry this substance down into the root zone and produce injury to the tree.

Leaf counts made on August 4 brought out the following points in regard to defoliation:

(a) The addition of potash to fertilizer treatment did not increase or decrease defoliation.

(b) The greater amounts of Cyanamid (700 pounds per acre) produced more defoliation than smaller amounts (300 pounds per acre).

(c) In general, there was greater defoliation in low than in high moisture treatments. This effect of moisture was greatest in sandy soil and only slight in sandy loam and loam soil.

From these data, it would seem as if the excess Cyanamid was the prime cause of injury, and that the potash had little or no effect on such injury.

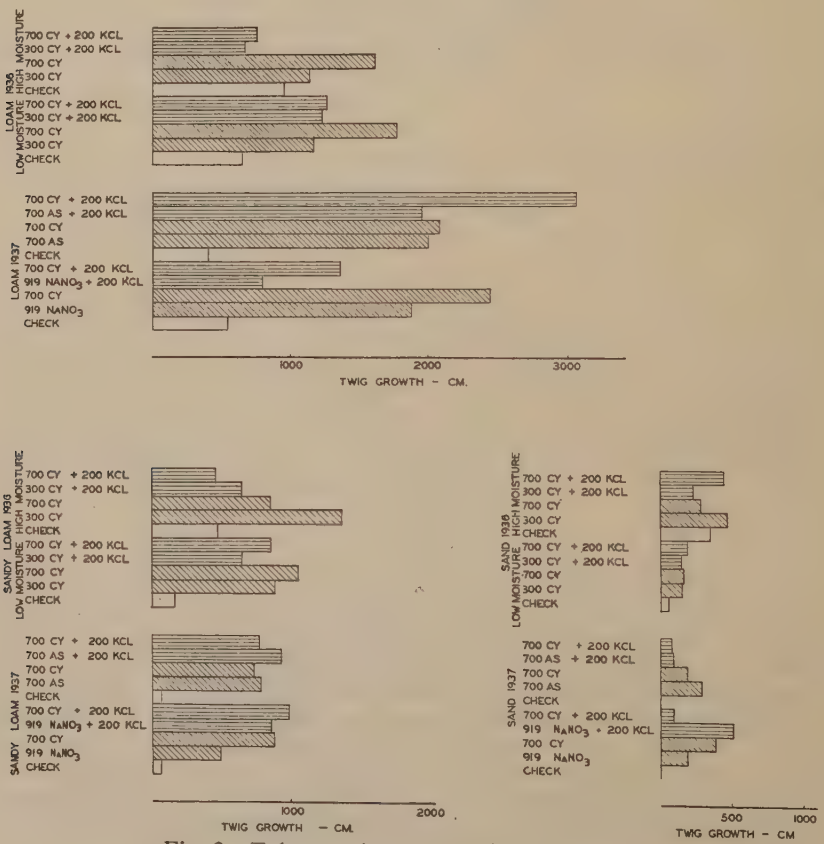

Fig. 2. Tub experiment. Total twig growth.

1937—Results in 1937 were measured by twig growth, blossom count, yield of fruit and general foliage conditions.

Total twig growth is shown in Fig. 2. The least growth was made by the several groups of check trees; in fact, in the sandy soil, these trees made no shoot growth at all. In sand, the addition of potash to trees receiving nitrate of soda produced a slightly better growth than those trees receiving nitrate of soda alone, but showed no beneficial effect in other comparisons. With trees growing in sandy loam, however, potash actually proved beneficial in every case in producing a slightly greater growth as compared with trees not receiving potash. In the case of trees grown in loam, only one comparison showed potash as being beneficial. Here, potash added to trees receiving Cyanamid and grown in a high moisture soil of the previous year produced the greater twig growth.

Foliage injury developed only on trees receiving Cyanamid fertilizer. In sand and sandy loam soils, the addition of potash did not reduce the burning in any way, trees receiving potash being just as badly burned as those which did not receive any of this fertilizer. In loam soils, where injury was not so severe, there was a slight indication

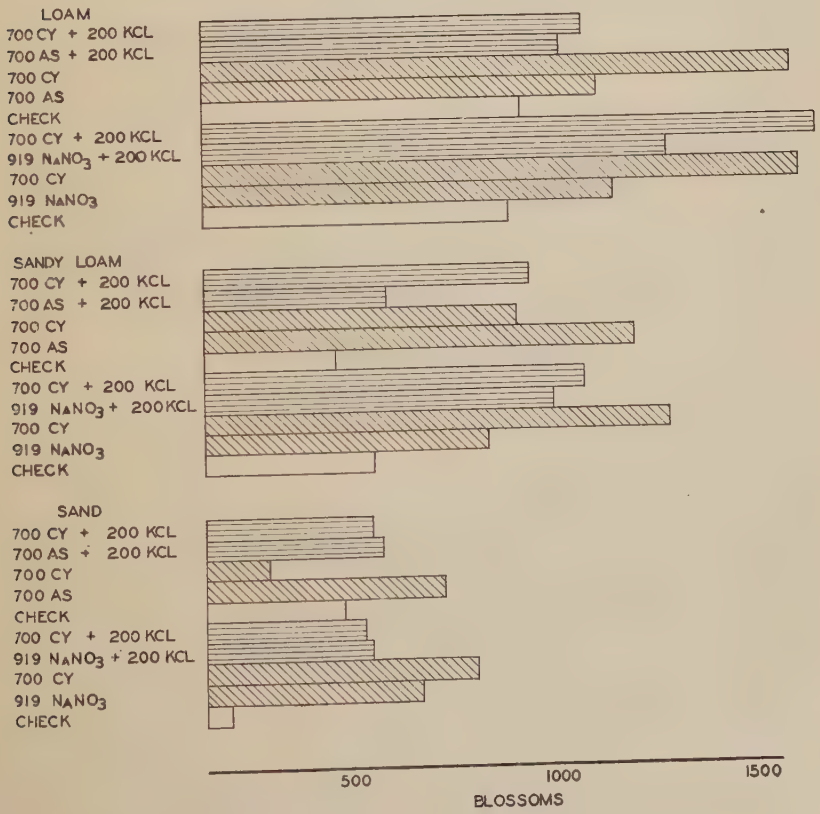

Fig. 3. Tub experiment. Number blossoms per tree.

that potash had reduced the amount of burning, but the evidence was too slight to justify any conclusion on this point.

Blossom production may be affected by soil and previous fertilizer treatment. To determine these effects, blossom counts were made in May and are shown in Fig. 3. When the various fertilizer treatments are grouped together, they show that those trees grown in sand produced 483 blossoms per tree, those grown in sandy loam produced 867, while those grown in loam produced 1,223 blossoms per tree. Clearly, the original soil had a marked effect on blossom production of these trees, due to or associated with the amount of vegetative growth produced by these different soils.

There seems to be no constant relationship between the addition of potash to the trees and blossom count, as can readily be seen by

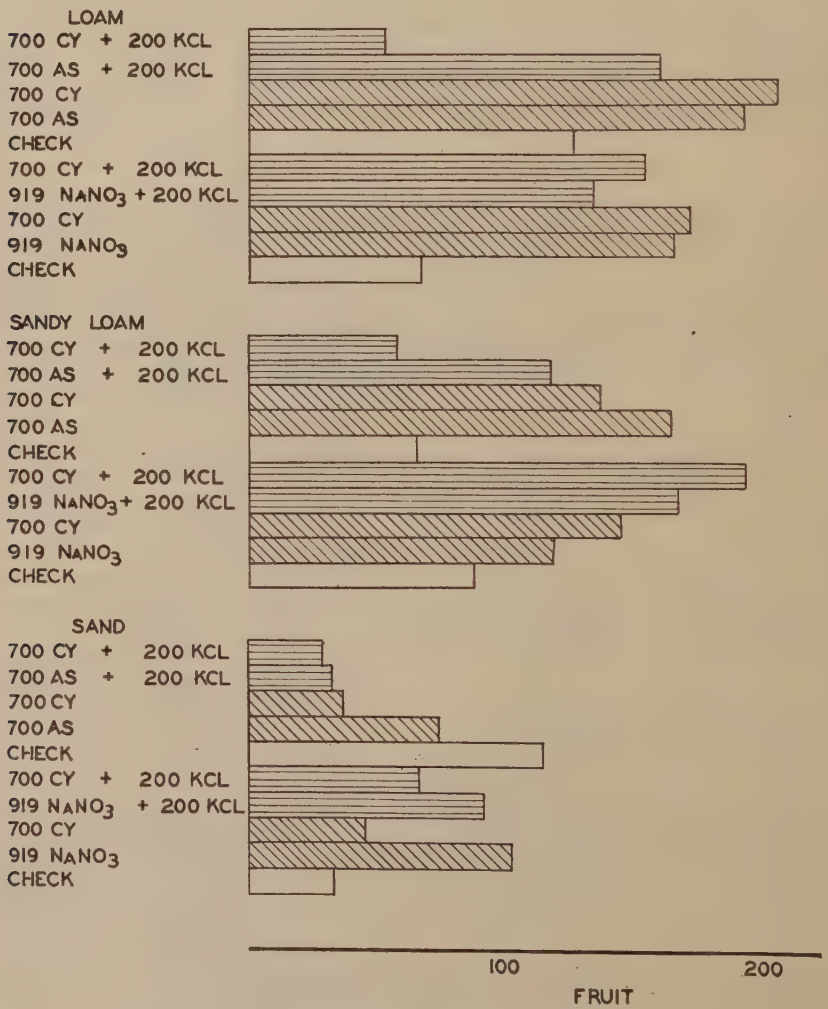

Fig. 4. Tub experiment. Number fruit per tree.

studying Fig. 3. In all but one case, the checks produced the least number of blossoms.

Fruit production, which would be affected by both the 1936 and 1937 treatments, is shown in Fig. 4.

Though the reduction in amount of fruit produced following potash application was slight and probably insignificant, the figures certainly afford no support to the belief that potash applications are likely to result in increased yield. Potash did not prove beneficial to the tree as far as the features measured were concerned. In fact, in several cases, it proved to be actually detrimental to the welfare of the trees.

Greenhouse Experiment

In order to make a further study of these fertilizers under a more completely controlled set of conditions, 100 cherry trees were grown in sand in the greenhouse, as already mentioned. Cyanamid and sulphate of ammonia were used with and without the addition of potash. The nitrogenous fertilizers were applied at the rate of 700 pounds per acre and potash at the rate of 200 pounds per acre. The trees were fertilized on February 3 and first showed injury on March 20. Foliage injury on trees receiving Cyanamid increased during the period of the experiment until by May 8, when the experiment was terminated, all the trees showed extensive foliage injury. This was evident whether or not the trees received potash along with the Cyanamid. Trees receiving sulphate of ammonia were in good condition on May 8 and possessed a healthy green foliage.

No growth comparisons were made because of the short period of the experiment and the fact that the trees were harvested on successive dates for chemical analysis.

The observations on the foliage reactions to the various treatments discussed above only help to confirm the conclusions based on the tub experiment that potash did not in any way alleviate the burning effect following Cyanamid applications, or improve the general condition of the trees.

Field Survey

In the fall of 1937, a survey was made of certain orchards in Michigan with the idea of trying to correlate tree performance with the potash content of the soil in which they were growing. Good and poor orchards were picked out and notes made on the general condition of the trees at the time when soil samples were obtained. Eighty-six soil samples were collected from the various fruit growing sections of the state at 6-inch and 12-inch depths and tested for available and reserve potash. The Spurway method of soil analysis was used in this work. Table 2 gives the results of these tests for reserve potash.

In general, the soils tested low in available potash and from low to high in reserve potash. Good, vigorous apple trees grew on soil containing just as much reserve potash as soil that produced poor trees. With peach trees, on the other hand, there was slightly more reserve potash in soil producing good trees than in soil producing poor ones. The best cherry trees also grew in soil containing slightly more reserve potash than in soil producing poor trees. The variation, however, was so great that these differences are hardly significant. Available potash

was low (0-30 pounds per acre) in nearly all cases and showed no relationship to growth.

From the data obtained in this survey, it seems very doubtful if the condition of the selected trees could be ascribed to the potash status of the soil.

The other factors in soil fertility were evidently of far greater importance in limiting growth than was the potash content of the soils.

Conclusion

The results obtained from these different experiments indicate that the use of potash cannot in any way counteract the foliage burning

Table 2. Potash content of orchard soils in relation to tree performance.

Apple Trees

Tree Performance	Reserve Potash in Soils (lbs. per acre reserve potash)								
	Good			Fair			Poor		
	No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling	
		6″	12″		6″	12″		6″	12″
	3	155	160	16	100	60	1	140	120
	5	125	105				2	140	120
	15	35	35				4	60	25
	18	160	160				13	45	40
	19	70	75				14	60	55
	35	20	10				17	155	145
	42	170	115				32	65	120
							33	50	30
							38	125	175
							40	35	50
Average		105	94.3		100	60		87.5	88.0

Peach Trees

Tree Performance	Reserve Potash in Soils (lbs. per acre reserve potash)								
	Good			Fair			Poor		
	No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling	
		6″	12″		6″	12″		6″	12″
	7	75	60	20	50	50	6	50	50
	9	50	55	21	30	40	23	30	50
	22	45	30	31	50	45	26	75	35
	24	90	90						
	27	85	75						
Average		69.0	62.0		43.3	43.3		51.7	45.0

Cherry Trees

Tree Performance	Reserve Potash in Soils (lbs. per acre reserve potash)								
	Good			Fair			Poor		
	No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling		No. of Orchard	Depth of Sampling	
		6″	12″		6″	12″		6″	12″
	29	130	50	37	55	45	30	175	110
	36	190	120				34	35	30
	43	75	75						
	44	240	165						
	45	35	35						
	46	130	50						
	47	50	25						
	48	185	60						
Average		129.4	72.5		55	45		105	70

resulting from late spring applications of Cyanamid. It also does not appear that potash is as yet a limiting factor in tree fruit production in Michigan.

OBSERVATIONS ON CERTAIN COATINGS USED IN GRAFTING THE APPLE

H. A. CARDINELL
Section of Horticulture

Protective coatings have long been used in grafting to seal the freshly cut tissue at the point of union of stock and cion. The main objective has been to prevent drying, though probably the coating likewise aids in keeping out insects and fungi. Most of the older coatings were grafting waxes of the so-called "hand wax" type. That is, they were more or less plastic or putty-like at working temperatures (40°-65° F.) and were applied by spreading over the surfaces to be covered by means of hand pressure. More recently the hand waxes have been gradually replaced by so-called "brush" waxes—materials that upon heating to 150°-200° F. are fluid and that consequently can be applied by means of a brush. The material preferably should be one that will adhere readily to either a moist or dry surface.

The black brush waxes that have largely replaced hand waxes have been satisfactory from the standpoint of covering and protecting the tissues to which they have been applied, but they have been comparatively expensive and require the added cost and trouble of a heating device to keep the wax in a brushing consistency. The difficulty of keeping wax warm has undoubtedly been the main factor that has caused investigators, nurserymen and manufacturers to search for a cold brushing mixture that would not injure plant tissue.

This article is a report upon experiments conducted with a number of different waxes, some of them proprietary materials sold under various trade names and others preparations made from formulae that will be given.

Fig. 1. The girdled section of a bridge-grafted tree coated with the standard home-made wax (No. 1), after weathering. The wax afforded protection early in the season, but owing to later cracking it is no longer of much value.

Methods and Materials

At the Graham Experiment Station near Grand Rapids, a nursery planting of young apple trees was available for these tests. It consisted of most of the standard apple varieties grown commercially in Michigan, together with a number of seedlings. For the most part the cleft graft was used on stocks ranging from three-fourths to one and one-half inch in diameter. The cions were not secured by tying but depended entirely on the pressure exerted by the split stock and the adhesive force of the wax to hold them in place.

Home-made Waxes—A home-made wax formula that has been in use for many years (5 lbs. resin, 1 lb. beeswax, ¼ pint raw linseed oil and ½ lb. powdered charcoal) was used as a standard with which to compare other materials. This is Wax No. 1, as given in Tables 1, 2, and 3. Various modifications of this formula were tried (see Table 1), e.g., using a smaller proportion of resin in Wax No. 2, using varying amounts of abietic acid in place of the resin in Waxes Nos. 3, 4, 5, and 6, doubling the amount of linseed oil and replacing the powdered charcoal with lampblack in Wax No. 19, and substituting Fuller's Earth for the powdered charcoal in Wax No. 20. These changes in formulae re-

sulted in some change in the melting or flow point of the several waxes and likewise in their susceptibility to cracking upon being exposed to the weather.

Commercial Trade or Proprietary Materials—Nine different trade or proprietary materials were used in the 1936 apple grafting trials and six in the 1936 pear trials. Five such materials were used in trials on

Fig. 2. The girdled section of a bridge-grafted tree coated with one of the proprietary preparations (No. 10), after considerable weathering. Notice that thus far it shows no cracks.

the apple in 1937, three of which had been used in 1936 and two of which were used for the first time in 1937. Information is not available as to their composition, nor is it known whether all or any one of them was the same in composition in 1937 as in 1936. They were simply obtained as samples of products being offered to the trade as grafting wax substitutes and for wound coverings. Some of them were obviously asphalt emulsions. The label on No. 14 stated that it was

made from pure Gilsonite asphalt, to which graphite, asbestos and tung oil had been added.

Results Obtained

The relative value of any grafting compound or wound dressing used in connection with grafting can be judged to some extent by its

Fig. 3. One of the home-made waxes (No. 20) after a season's weathering. Note that it has neither cracked nor scaled off to any considerable extent.

(a) cracking, (b) melting and running off the graft and (c) the length of time during which it adheres to the treated surfaces under exposure to ordinary weathering influences. More important, however, is the possible injurious influence on the tissues of the stock or cion. This can be more or less accurately measured by the stand of the

Table 1. Comparison of graft coatings on apple—1936.

Wax	Material	Cions set No.	Cion stand per cent	Total average growth per cion cm.	Flow point °F.	Wax not cracking per cent
	HOME-MADE WAXES					
1.....	Resin, 5 lbs.—Beeswax, 1 lb.—Raw linseed oil, ¼ pt.—Lampblack, ½ lb.....	285	88	68	204	60
2.....	Same as No. 1, except 2½ lbs. resin.....	107	93	91	186	3
3.....	Same as No. 1, except abietic acid replaced resin.....	111	90	124	204	0
4.....	Same as No. 3, except ¾ as much abietic acid was used.....	119	92	110	150	0
5.....	Same as No. 3, except ½ as much abietic acid was used.....	84	76	90	141	0
6.....	Same as No. 3, except for twice as much abietic acid.....	82	82	117	159	0
19.....	Same as No. 1, except oil was doubled and carbon black replaced lampblack.....	64	95	158	133	18
20.....	Same as No. 19, except Fuller's Earth replaced black powder.....	64	97	156	131	38
	COMMERCIAL TRADE OR PROPRIETARY MATERIALS					
7.....	"Static" asphalt emulsion.....	90	96	121	—	0
8.....	Same, plus 4 per cent asbestos.....	88	94	107	—	25
9.....	Same, plus 12 per cent asbestos.....	90	94	87	—	25
10.....	Foster's I. B. M. asphalt Dispersion.....	98	95	115	—	1
11.....	"Tree Seal" (western).....	94	81	67	—	35
12.....	"Tree Seal" (eastern).....	120	68	51	—	6
13.....	"Kelsanite" (asphalt-latex).....	108	38	27	—	34
14.....	"Asgum Plastic".....	108	40	21	—	68
15.....	"Tremco 909 Grafting Comp.".....	100	None	—	—	100

Table 2. Grafting wax trials with apple—1937*.

Material No.	Cions set No.	Cions alive per cent	Total average growth per cion cms.
1.....	42	100	116
7.....	22	100	151
10.....	20	100	96
15.....	20	5	5
211.....	12	92	119
A.....	8	63	27

*No. 211: A thick wax known as "Standard Wax 211" was used as prepared by the manufacturer. It is too thick to be applied with a brush without thinning or heating and therefore it was applied by means of a spatula. It remained soft and plastic, seldom cracked and remained waterproof.

No. A: "Graftex", a new compound recently placed on the market. It is a greenish grey mixture, very plastic and sticky and appears to have a low melting point since it cools and warms rapidly with changes in temperature.

Fig. 4. The standard home-made wax (No. 1) after a season's weathering. It has cracked rather badly. If cracks develop before a good union between stock and cion has been effected, the cut surfaces and cracks should be rewaxed.

cions and the amount of growth that they make. Data on all of these criteria are presented in Tables 1-3 presenting the results obtained with apple grafts in 1936 and 1937, and with pear grafts in 1936.

It will be noted that from the standpoint of freedom from cracks most of the preparations were far from perfect, though despite this fault good stands of the cions were obtained. All of the home-made waxes gave satisfactory results, as judged by percentage stand of cions, and the amount of growth that they made. Several of the modifications of the standard formula (No. 1) appeared to be preferable to it, especially in view of their somewhat lower melting points. Home-made wax No. 20 seemed to be especially promising. Similarly several of the commercial trade preparations gave good results, though Nos. 12, 13, 14 and 15 cannot be recommended on the basis of these trials.

Table 3. Grafting wax trials with pear—1936.

Material No.	Cions set No.	Cions alive per cent
10	12	100
8	14	93
1	37	87
12	28	71
14	22	68
13	10	50
15	35	3

Fig. 5. Typical results attending the use of a wax that contains some injurious ingredient or combination. Note the sunken dead bark areas on the stock.

MAHALEB VS. MORELLO ROOT STOCKS FOR EARLY RICHMOND CHERRIES

WALTER TOENJES
Section of Horticulture

The cherry root stocks commonly used in the propagation of the sour cherry influence considerably the stature and form of tree of the variety worked upon them. The strong vigorous-growing Mazzard stock, when budded or top-worked to the sour cherry, produces a larger and stronger growing tree than does the smaller growing Mahaleb, though it is not generally recommended for Michigan conditions because its roots are more susceptible to winterkilling than are those of the Mahaleb. Morello stocks are not in common use in the United States, though there has long been considerable interest in them.

In the spring of 1931 a number of Early Richmond trees were planted at the Graham Horticultural Experiment Station near Grand Rapids, part of which were on Mahaleb and part on Morello roots. They were grown on the same type of soil and afforded the same cultural treatments. The trees on Mahaleb stock are upright-spreading in habit with relatively thick branches and shoots, while those on Morello stock

Fig. 1. Early Richmond on Mahaleb stock. Note the upright-spreading form of tree and its relative size and vigor as compared with the tree shown in Fig. 2.

Fig. 2. Early Richmond or Morello stock. Note the low spreading habit of growth and its small size as compared with the tree shown in Fig. 1.

have assumed more or less the natural growth habit in stature and form of the Morello (See Figs. 1 and 2). They are smaller in size, spreading in form, with slender drooping branches and slender trunks. Tree growth measurements were made at the end of the seventh season. The trees on the Mahaleb had an average trunk circumference of 14.3 inches, an average tree height of 11.0 feet and an average branch spread of 13.5 feet. Similar averages for the trees on Morello stock were 8.5 inches, 7.0 feet and 9.1 feet, respectively.

Observations indicate that there is little or no difference in the size of the fruit as grown on these two stocks. The trees growing on the Morello stock showed a tendency toward earlier and somewhat heavier bearing than those on the Mahaleb stock, but this advantage is more than offset by the greater fruit bearing surface of the latter and their larger total yields. Though the Morello stocks may possess some advantage for trees raised in the home garden where space is limited, they do not seem to have a place in the commercial orchard.

KILLING TREES WITH KINDNESS

T. A. MERRILL
SECTION OF HORTICULTURE

The ultimate objective of every fruit grower is to grow strong, healthy, vigorous trees that will be long-lived and capable of bearing heavy crops of salable fruit. Attainment of their objectives depends on the selection of good varieties, planting the trees in a suitable soil,

Fig. 1. Southwest half of tree showing results from painting trunk with paradichlorobenzene dissolved in linseed oil. Leaves on the other half of the tree were badly wilted and dwarfed at the time picture was taken. This tree probably will not recover.

proper cultural practices, fertilization, insect and disease control, pruning and a number of other factors. If the trees do not measure up to expectations in growth and production, it is usually due to a failure on the part of the owner to provide for them the requisite environmental conditions and care. Not infrequently, however, he is too anxious for them to succeed and (thinking that if a little of some treatment or practice is good a lot will be better), he overdoes with fertilizer or with spray application or with cultivation or pruning or in some other manner. Attention is here called to instances where the writer has been called to diagnose the cause of serious trouble and suggest remedial measures.

Fig. 2. This tree lost its leaves soon after growth started in the spring of 1938. The more serious injury on this tree than the one shown in Fig. 1 is due to smaller trunk diameter and thinner bark.

Spraying with Materials not Needed—Many unnecessary cases of arsenical injury have been observed on peaches, apples, and other tree and bush fruits. On one occasion the writer observed a two-year-old peach orchard in which most of the trees had been killed outright as a result of arsenical spray applications containing no corrective for arsenical injury. In the first place it is unnecessary to spray peach trees with an arsenical until they begin to bear fruit, for leaf eating

insects seldom trouble peach foliage. In the second place, zinc sulphate, or some other corrective, should always be added to the spray when arsenic in any form is used on peach foliage. Zinc sulphate has no insecticidal value and very little, if any, fungicidal value, but failure to use it usually results in serious foliage injury to peach foliage and twigs, premature defoliation and often death of the trees.

Fig. 3. Showing blackened condition of cambium after painting trunk of tree with paradichlorobenzene dissolved in linseed oil. The cambium was dead on all trees so treated at time pictures were taken.

Too Heavy Applications of Insecticides—A short time ago a peach grower complained because his peach trees were dying. Inspection disclosed that, though soil conditions seemed favorable and cultural operations seemed to have been properly carried out, only a few of the trees in a block of 300 had fairly normal leaves. A few trees had green leaves on one side but the leaves on the other side of the trees were dead (Fig. 1). Other trees were still in possession of their leaves but they were small, yellowish, and more or less wilted, and still other trees had lost all of their leaves (Fig. 2). The grower made the remark that shortly previous to the inspection he had never seen peach trees with better trunks and so free from gum. However, the trunks were off color and upon examination it was found that the cambium was dead—apparently only recently killed. During the summer of 1937 there had been some borer injury and in the fall the grower decided to treat all his trees to stop the trouble. To do this he dissolved paradichlorobenzene in linseed oil, because cottonseed oil, which should be used, was a little more expensive. Thinking that if a little of the material would be good a lot would be better, he painted with it the entire trunks of all the trees from the ground level to the crotches. In drying, the oil formed a kind of "skin" and the fumes of the crystals penetrated the bark and killed the cambium (Fig. 3).

Paradichlorobenzene has its place in the control of fruit tree borers—but not dissolved in linseed oil and applied as this fruit grower applied it. The application of paradichlorobenzene dissolved in raw cottonseed

A B C

Fig. 4. "A" shows Montmorency tree planted in spring of 1937 to which one-fourth pound of ammonium sulphate was added to soil at time of planting. "B" and "C", trees that were re-set in 1938 to which sulphate was also added to soil at time of planting. At the time the pictures were taken leaves were badly burned and root cambium was dead.

oil anytime between September 1 and April 15 will control the lesser borers which work in the trunk, crotches, and large limbs of the peach tree. It should not be applied, however, when the temperature is 50° F. or below, as the material will crystallize. The mixture—one pound of paradichlorobenzene dissolved in two quarts of raw cottonseed oil—painted upon the infested areas (never around the entire branch or trunk) after removal of the gum will kill practically all of the borers. If it is applied without removal of the gum it will kill about 90 per cent of them.

Too Much Fertilizer—On another occasion one nurseryman stated that a fruit grower with whom he had done business for a number of years had planted a small block of Montmorency cherry trees in the spring of 1937. In the spring of 1938 most of the trees were dead and the grower believing the nurseryman to be at fault in supplying trees with which something had been the matter, asked the nursery to replace them. When the writer was called into consultation by the grower and nurseryman, many of the trees that were planted in 1938 were dying. Tip and marginal burning of the leaves was prominent. Many leaves were dead, some had fallen. In some trees the cambium layer was dead and their roots had turned black. The writer suspected that the injury may have been due to too heavy an application of fertilizer.

Upon questioning the grower admitted, rather reluctantly, that both seasons he had applied sulphate of ammonia at the time of planting. He added, "Well, gentlemen, now I will tell you just why I added sulphate to those trees. Mr. X, a competitor of yours (the nurseryman) told me he could sell me better trees. Inasmuch as I had done business with you for a number of years, I more or less wanted to prove that he was mistaken in his statement. With this idea in mind, I decided that a little sulphate would help the trees out." Fertilizer application may be desirable the year that trees are planted, depending on conditions, but anyone using it should remember that the root system is confined to a very small area and anything more than a very light application to that area is likely to result in a toxic concentration that may cause burning or even be fatal to the tree.

This article is not written with the idea of discouraging the use of the materials mentioned, but to caution against the killing of trees with kindness. These materials and all others that have their place in the orchard should be used with caution, in the proper amounts and at the proper time.

BULLETIN REVIEWS

Circ. Bul. 166.—Water Conditioning for Greenhouses.—Spurway, C. H. and Wildon, C. E.—A progress report on a method of water conditioning for greenhouses, lawns and gardens in order to maintain suitable degrees of acidity or alkalinity in the soil. The installation and operation of the apparatus, which neutralizes the carbonate hardness of the water with phosphoric acid, is described. (10 pp., 1 table, 2 figs.)

Tech. Bul. 159.—The Manganese Content of Feedstuffs and Its Relation to Poultry Nutrition.—Schaible, P. J., Bandemer, S. L. and Davidson, J. A.—Perosis, or slipped tendon, in chickens is shown to be caused by either a deficiency of manganese in the ration or an excess of mineral concentrates which reduced the availability of this element.

The minimum manganese requirement for chicks and hens on normal mineral rations was determined to be approximately 40 mg. per kg. of ration.

All compounds and ores of manganese used were found satisfactory as supplements except the ores rhodonite and rhodochrosite; the oxide ores were the most economical.

A wide variety of feedstuffs was analyzed for manganese and the concentration was found to vary with such factors as species of plant, time of harvest, stage of maturity, fertilization and soil reaction. Because of this variation, it is recommended that poultry rations be augmented with manganese in order to insure a sufficiency of this element at all times. A compilation of the results of the analyses of feedstuffs for manganese is given in an appendix. (32 pp., 18 tables.)

Tech. Bul. 160.—Physiological Investigations of Red Raspberry Plants Inoculated with Red Raspberry Mosaic.—Grigsby, B. H.—Red raspberry plants inoculated with the virus causing red raspberry mosaic exhibit the usual mottling of a mosaic disease under relatively cool temperature conditions. When the temperature is 75° F. or above the symptoms are masked and the leaves appear normal.

In all plants in which the virus was present chlorophyll content was somewhat greater than in healthy plants. In virus-infected plants the formation of extra layers of chlorophyll-bearing palisade tissue was observed and could account for the increased chlorophyll content. Sucrose was present in increased amounts and all other carbohydrates in decreased amounts in diseased as compared with healthy plants.

Nitrogen studies demonstrated the presence of more total nitrogen in the healthy plants but more ammonia nitrogen in mosaic-infected plants. This indicates that the virus had interfered with the process of protein synthesis.

It was found that the rate of photosynthesis was decreased in plants having marked symptoms of the disease and progressed more rapidly in normal plants. Respiratory rate, on the contrary, was increased in the virus-infected plants. Seasonal variations were demonstrated for both processes.

Rate of water loss by transpiration was highest in those plants infected with the virus.

Stomatal counts showed a greater number per unit area on the diseased leaves. Such leaves, however, are usually smaller than healthy leaves of the same age. Analyses of the ash of leaf tissue showed a greater percentage of ash in tissue taken early in the morning than in similar tissue taken late in the afternoon. It is suggested that the progressive dwarfing of canes in an infected planting is due to the fact that the virus slows down photosynthetic processes and speeds up respiratory activity. Thus the infected plants are starved and eventually die. (27 pp., 11 tables, 4 figs.)

Memoir 3.—Studies on the Trematode Parasites of Ducks with Special Reference to the Mallard.—Gower, W. Carl.—The report is divided into two parts, the first, dealing with trematodes found in Michigan ducks, the second, a check-list of all species of trematodes reported from ducks.

More than 200 ducks, coming from seven widely scattered areas in Michigan were examined. From these ducks, 15 species of trematode worms were recovered, three of which are named as new species. One new genus is described. Artificial infections were obtained in the case of four species. *Amphimerus elongatus* n. sp. is considered the most important pathogene to the hosts. This fluke, living in the pancreas and liver of ducks, causes considerable damage, especially to young ducks. Partial life history records of *Amphimerus elongatus* and *Zygocotyle lunatum* were obtained. In general, under normal conditions, the trematodes studied have little pathological effect on the host. However, as in the case of practically all internal parasites, when unusual complications or the normal host-parasite balance is upset, serious damage to the host may result.

The second part of the report is a compilation from the literature of the trematodes that have been recorded from ducks, and includes 109 species belonging to 46 genera and 17 families. A key to the genera, and a host list are also included. Family and generic diagnosis are given, with the species listed under the genera. Principal synonyms, hosts, distribution, and life history notes (where known) are given for each species. (94 pp., 3 figs.)

JOURNAL ARTICLE ABSTRACTS

A Bottle Sterilizer for Small Capacity Plants.—Marshall, Roy E.—Fruit Prod. Jour. 18 (1): 8-9. 1938. [Journal Article No. 175 (n. s.) from the Michigan Agricultural Experiment Station.]—Directions are given for the construction of a U-shaped metal tube through which beverage bottles may be passed for sterilization in a hypochlorite solution. The sterilizing tube, when operated at a capacity of 225 quart bottles per hour, permits two bottles to fill with the sterilizing solution and two to empty simultaneously and the length of the tube is such that 2½ minutes elapse from the time a bottle is completely filled with chlorine solution until it is fully drained. Observations indicate

that the bottles were completely sterilized in this time. Suggestions are given for the construction of units having greater capacity.

The Microscope in the Production of High Quality Milk.—Bryan, C. S., Turney, G. J., Fox, W. K., Begeman, L. H., Miles, X. A. and Bryan, J. S.—Jour. of Milk Technology. 1(5): 26-34. 1938. [Journal Article No. 327 (n. s.) of the Michigan Agricultural Experiment Station.]—This study was undertaken to determine the original source of the bacteria found in poor quality, high count raw milk, and, utilizing this information, to suggest the probable source of contamination to the dairyman in order that he may correct or improve his procedure of milk production. The milk samples were checked by quality tests for milk in addition to the microscopic examination. The results of the methylene blue reduction test, sediment test, direct microscopic count, and temperature readings of the milk as it arrives at the plant were utilized in arriving at a score on a patron quality report.

The majority of raw milk samples having a count of less than 100,000 bacteria per c.c. (class I) were of class 1 methylene blue and classes 1, 2 and 3 of the sediment test. Practically all of this milk arrived at the plant at a temperature of 60° F. or lower and with a passing score, while during the warmer summer months the temperature was higher and the number of milk samples with a score below passing increased.

The samples in class II of the microscopic examination (100,000 to 500,000 bacteria per c.c.) were in class 2 and some in class 3 of the methylene blue test, and in classes 2 and 3 of the sediment test. Dirty utensils, poor cooling, and dirty cows or barn were the major sources of contamination in this group. A number of the samples had a temperature of 65° F. or above. Approximately 50 per cent of this milk had a passing score.

The bulk of milk sent to Lansing over a six months period was of Class I and II on the basis of the bacteria count. When the bacteria count was in class III (500,000 to 1,000,000), the methylene blue rating dropped to classes 2, 3, and 4, with the greatest portion of the milk showing a larger amount of visible dirt as indicated by the sediment test. In addition to individual cases where poor cooling, utensils, dirty cows, or barn were the chief sources of contamination, the types of microbes found in many samples would indicate the necessity of a thorough cleanup of all phases of milk production, and is indicated on the score card as poor production. The temperature of this milk was high, and practically none of this milk rated a passing score. The milk with a count of more than 1,000,000 per c.c. (class IV) was mainly of classes 3 and 4 methylene blue, and 2, 3 and 4 sediment test. The types of contamination responsible for this high count milk were similar to those of class 3 (microscopic count). The temperature of most of this milk as it arrived at the receiving plant was above 65° F. and none rated a passing score.

The Bulletins of this Station are sent free when available to such individuals as may request them. Please request only those actually needed. Address all applications to the Director, Agricultural Experiment Station, East Lansing, Michigan.

NATURE OF PUBLICATIONS—

Four series of publications are issued by the Experiment Station—Special, Circular, Technical, and Quarterly. In addition to these the Extension Service issues its regular series, as well as those of the club service.

Special bulletins are of a popular nature, and deal with special lines of work.

Circulars are briefly and concisely written discussions of a popular nature.

Technical bulletins, as the name implies, are devoted to reports of scientific research and designed more especially for use of other investigators, instructors and students.

The Quarterly bulletin contains contributions by all sections of the Experiment Station. It is issued during February, May, August, and November of each year. The Quarterly also contains a list of available bulletins.

MAILING RESTRICTIONS—

Single copies of bulletins are for free distribution as long as the supply lasts. Quantities of bulletins may be obtained at cost.

Requests for bulletins should be limited to those actually needed.

Bulletins are not intended to be used as text books in classes, but, upon application, libraries of colleges and public schools of Michigan will be supplied with a few copies for class reference.

All applications for bulletins should be addressed to V. R. GARDNER, DIRECTOR, East Lansing, Michigan.

LIST OF AVAILABLE BULLETINS

Regular Bulletins—

R-262 Suggestions on Planting Orchards.

Special Bulletins—

S- 71 Studies in the Range and Variation of the Per Cent of Butterfat in the Milk of Individual Cows.
S- 83 Key to Orthoptera of Michigan.
S- 94 The Financial History of a Twelve-Year-Old Peach Orchard.
S- 98 Vinegar.
S-101 Oats in Michigan.
S-106 Sugar Beet Growing in Michigan.
S-109 Crop Varieties for Michigan.
S-110 Special Report of the Upper Peninsula Experiment Station.
S-124 The Colorimetric Hydrogen-ion Determination as a Means of Locating Faulty Methods at City Milk Plants.
S-126 An Analysis of the Peach Variety Question in Michigan.
S-130 The Clovers and Clover Seed Production in Michigan.
***S-133 Fertilizers—What They Are and How to Use Them.**
S-141 Profitable Pruning of the Concord Grape.
S-142 Grafting in the Apple Orchard.
S-150 Emergency Hay and Pasture Crops.
S-151 Buckwheat in Michigan.
S-153 Peppermint Growing in Michigan.
S-156 Investigation With Strains of Beans.
S-164 Diagnosing Orchard Ills.
S-167 Chicory Growing in Michigan.
S-170 The Detroit Milk Market.
S-171 Farmers' Co-operative Buying and Selling Organizations in Michigan.
S-172 Farm Real Estate Assessment Practices in Michigan.
S-175 The Rural Cemetery.
S-178 Michigan Raspberry Diseases.
S-180 The Soils of Michigan, Grayling Sand.
S-182 Strawberry Growing in Michigan.
S-184 Size of Peaches and Size of Crop.
S-185 Roadside Marketing in Michigan.
S-189 The Marketing of Michigan Milk.
S-190 Oak Forests of Northern Michigan.
S-191 Barley for Michigan Farms.
S-192 Causes and Effects of Soil Heaving.
S-194 The Use of Peat in the Greenhouses.
S-195 Maintaining the Productivity of Cherry Trees.
S-196 The Farm Woodlot in Michigan.
S-197 Oat Tests at the Michigan Experiment Station.
S-198 Combine Harvester Threshers in Michigan.
S-199 Studies in Swine Feeding, Parts I, II, III.
S-200 Hogging Off Corn.
S-201 The Influence of Sugar and Butterfat on the Quality of Ice Cream.
S-203 Spraying Materials and the Control of Apple Scab.

*Bulletins listed in bold face type are recent publications of this Station.

S-204 Investigations of Corn-Borer Control at Monroe, Mich.
S-205 Soil Fertilization for Sugar Beets.
S-207 Public Health and Educational Service in Michigan.
S-208 Service Institutions and Organizations in Town-Country Communities.
S-209 Consumer Demand for Apples in Michigan.
S-210 Corn Growing in Michigan.
S-213 Investigations with Oat Varieties and Diseases.
S 214 Insects and Allied Pests of Plants Grown Under Glass.
S-215 Successful Farm Practices in the Upper Peninsula.
S-217 Marketing Michigan Beans.
S-218 Spray Injury Studies No. I.
S-219 Spray Injury Studies No. II.
S-220 Comparisons of Methods of Making Spray Applications.
S-221 Controlling the Codling Moth in Southwestern Michigan.
S 222 Garden Roses.
S-223 Bald Rock Wheat.
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S-227 Motor Truck Marketing of Michigan Fruits and Vegetables.
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MOTTS, G. N., Ph. D....Res. Asst. in Economics
ULREY, O., Ph. D.....Res. Asst. in Economics
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PETTIT, R. H., B. S....Consulting Entomologist
SHERMAN, FRANKLIN, M. S....Res. Asst. in Ent.
ATCHLEY, F. M., M. S..Res. Asst. in Farm Man.
WRIGHT, K. T., M. S...Res. Asst. in Farm Man.
EVERSON, GLADYS, M. S.....Asst. in Home Ec.
GRISWOLD, RUTH, M. S..Res. Asst. in Home Ec.
GROSS, IRMA H., Ph. D....Res. Asst. in Home Ec.
HAWKS, JEAN E., Ph. D..Res. Asst. in Home Ec.
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PORTER, THELMA, Ph. D..Res. Asst. in Home Ec.
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WILDON, C. E., M. S.....Res. Asst. in Hort.
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DAVIDSON, J. A., B. S..Res. Assoc. in Poul. Husb.
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HOFFER, C. H., Ph. D....Res. Assoc. in Sociology
HONIGSHEIM, PAUL, Ph.D..Res. Assoc. in Sociology
THADEN, J. F., Ph. D....Res. Asst. in Sociology
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COOK, R. L., Ph. D.....Res. Asst. in Soils
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VEATCH, J. O., A. B.....Res. Prof. in Soils
WEIDEMANN, A. G., M. S....Res. Asst. in Soils
WOLFANGER, L. A., Ph. D....Res. Assoc. in Soils
BATEN, W. D., Ph. D.....Res. Assoc. in Statistics
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*As of June 30, 1938.